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Characteristics of Deepwater Oil and Gas Distribution along the Silk Road and Their Controlling Factors

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Abstract: Deepwater regions have emerged as pivotal domains for global oil and gas exploration and development, serving as strategic alternatives to conventional resources. The Silk Road region is distinguished by its abundant oil and gas reserves and stands as a leading arena for worldwide exploration and development in the oil and gas sector. Since 2012, a series of atmospheric fields have been discovered in the deep sea of the Luwuma Basin and the Tanzania Basin, with cumulative recoverable reserves reaching 4.4×10^{12} and 8.3×10^{11} m^3, including multiple oil and gas fields ranking among the top ten global discoveries at that time. Profound advancements have been achieved in the exploration of deepwater oil and gas reserves along the Silk Road. However, deepwater oil and gas exploration presents challenges, such as high development costs and risks, leading to certain areas remaining underexplored and exhibiting a relatively low level of exploration activity, thereby hinting at considerable untapped potential. Deepwater sedimentary basins along the Silk Road predominantly adhere to a distribution pattern characterized as "one horizontal and one vertical". The "horizontal" dimension refers to the deepwater basin grouping within the Neo-Tethys tectonic domain, primarily extending from east to west. Conversely, the "vertical" dimension denotes the deepwater basin grouping along the East African continental margin, predominantly extending from north to south. Recent discoveries of deepwater oil and gas reserves validate the presence of foundational elements within Silk Road basins conducive to the formation of substantial oil and gas reservoirs and the establishment of efficient migration pathways. Despite these achievements, exploration activities in deepwater oil and gas resources along the Silk Road remain relatively limited. Future exploration endeavors in deepwater regions will predominantly focus on identifying structural and lithological traps. In the deepwater areas of the Bay of Bengal, the emphasis is on lithological traps formed by Neogene turbidite sandstone deposits. In the deepwater regions of Pakistan, the focus shifts to lithological traps emerging from Neogene bio-reefs and river-channel sandstone accumulations. Along the deepwater coastline of East Africa, the focus is on lithological traps formed by nearshore Mesozoic–Cenozoic bio-reefs and seafloor turbidite sandstone formations. Within the deepwater regions of Southeast Asia, the primary objective is to locate large structural-type oil and gas fields. Analyzing the characteristics of oil and gas discoveries in deepwater areas aims to enhance the theory of the control of the formation of deepwater oil and gas, providing valuable insights for predicting future exploration directions.

Keywords: Silk Road; deepwater oil and gas; petroleum exploration activities and challenges; deepwater sedimentary basins; material foundation; migration pathway

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1. Introduction

Currently, the global landscape of oil and gas exploration and development is marked by an escalating trend in reserves and production. The focal point of this exploration has progressively shifted toward deep sea, deep strata, and unconventional aspects [1–6]. The initiation of deepwater oil and gas exploration dates back to the late 1970s, and as of now, global deepwater regions are in the early stages of exploration, harboring significant potential and opportunities for the discovery of giant oil and gas fields. Advances in offshore geophysical exploration and deep-sea drilling technologies [7] have facilitated the shift from shallow waters to deep and ultradeep waters in global offshore oil and gas exploration. This transition has resulted in a surge of deepwater oil and gas discoveries, with more than half of the significant findings occurring in these deepwater areas [8]. There is a forecast that up to 40% of future oil and gas reserves may be located in deep-sea regions [9]. Based on exploration experiences, it is estimated that global offshore areas contain over 120 billion tons of undiscovered oil and gas resources, with a substantial portion situated in deepwater regions [3]. Given these abundant resources and decreasing development costs, deepwater oil and gas exploration has emerged as a central focus for global oil and gas exploration, representing a pivotal domain for future development [10,11]. At present, the deepwater basins that harbor significant oil and gas resources are primarily located in the East African region, South China Sea, northwestern Australian continental shelf, Gulf of Mexico, eastern Brazilian continental margin, western African continental margin, and central Norwegian continental shelf. These regions are predominantly situated along passive continental margins, forming an overall distribution pattern of “three vertical and two horizontal” [12–15].

Global deepwater oil and gas resources are abundant, establishing a new frontier that supports the future development of international oil companies. As oil and gas exploration technology advances and exploration activities persist, the volume of deepwater oil and gas resources has grown rapidly, positioning it as a significant player in the global energy market [9,16]. In the past decade, newly discovered offshore oil and gas reserves have accounted for 60% of the global total, with the deepwater to ultra-deepwater sector contributing 61.99% of these discoveries [17]. The regions along the Maritime Silk Road, hereinafter referred to as the Silk Road, harbor numerous deepwater basins, making it a global hotspot for oil and gas exploration. It is also a primary focus for China’s offshore oil and gas exploration and development cooperation, fostering collaboration on energy resources with relevant countries. This is of utmost importance for ensuring national energy security and advancing the vision of the “21st Century Maritime Silk Road”.

Deepwater basins along the Silk Road are primarily situated in the Neotethyan Basin and the East African continental margin. These areas are characterized by numerous basins, diverse types, and multiple structural and sedimentary epochs, providing favorable conditions for oil and gas reservoirs with significant resource potential. To date, 54 deepwater oil and gas discoveries have been confirmed, with gas-dominated fields being prevalent. The reservoirs primarily consist of deepwater turbidite sandstones and deltaic–littoral sandstones. Previous studies in this region have predominantly concentrated on individual basin oil and gas geology, regional structural–sedimentary evolution, basin geological structures, the distribution and prediction of source rocks, oil and gas potential, and exploration directions. There has been limited systematic geological analysis from a regional deepwater oil and gas accumulation perspective [18–21].

Furthermore, the current challenges faced by deepwater oil and gas exploration, such as high development costs and significant exploration and development risks, underscore the importance of studying the distribution characteristics and exploration patterns of deepwater oil and gas. Leveraging data from oil and gas field databases such as IHS Markit and Wood Mackenzie [22,23], alongside recent data on oil and gas exploration discoveries and evaluations, this study conducts a comprehensive analysis of petroleum geological conditions in various regions along the Silk Road. It explores source rocks, reservoirs, and cap rocks; investigates distribution patterns of deepwater oil and gas; summarizes reservoir characteristics; examines the controlling factors behind major oil and gas field formation in deepwater basins; and outlines future directions for deepwater oil and gas exploration.

This endeavor provides valuable insights for the advancement of cooperative oil and gas exploration along the Maritime Silk Road.

2. Geological Background

The Silk Road mainly includes the Indian Ocean coast and Southeast Asia, involving the Asia Pacific, East Africa, and other regions, with numerous sedimentary basins developed. The prevailing structural configuration of the Silk Road basins is attributed to the fragmentation of the Gondwana supercontinent, commencing during the Jurassic period. This process originated from the collision of the Eurasian Plate, the Indo-Australian Plate, and the Pacific Plate. This geological evolution involved intricate phenomena, including complex faulting, separation events, the effusion of basaltic lavas, and collision occurrences [24,25]. These processes collectively resulted in the formation of complex structural patterns. The geological record of this region is replete with consequential tectonic episodes, such as supercontinent breakup, seafloor spreading, and collision-related orogeny, leading to diverse plate boundaries encompassing divergent, convergent, and transform margins. Consequently, this region stands out as one of the most tectonically active areas globally [26–28].

The primary tectonic framework of this region primarily comprises landmasses that have undergone a series of geologic events, including rifting, collision, and amalgamation across different geological epochs. This prolonged process of landmass amalgamation facilitated complex structural and sedimentary transformations, ultimately leading to the formation of sedimentary strata of varying ages overlying crystalline basement rocks. As a consequence, the region hosts a diverse range of sedimentary basins spanning from the Paleozoic to the Cenozoic (Figure 1). Notably, the Mesozoic and Cenozoic periods represent the principal epochs during which these basins formed, housing significant oil and gas resources along the Silk Road.

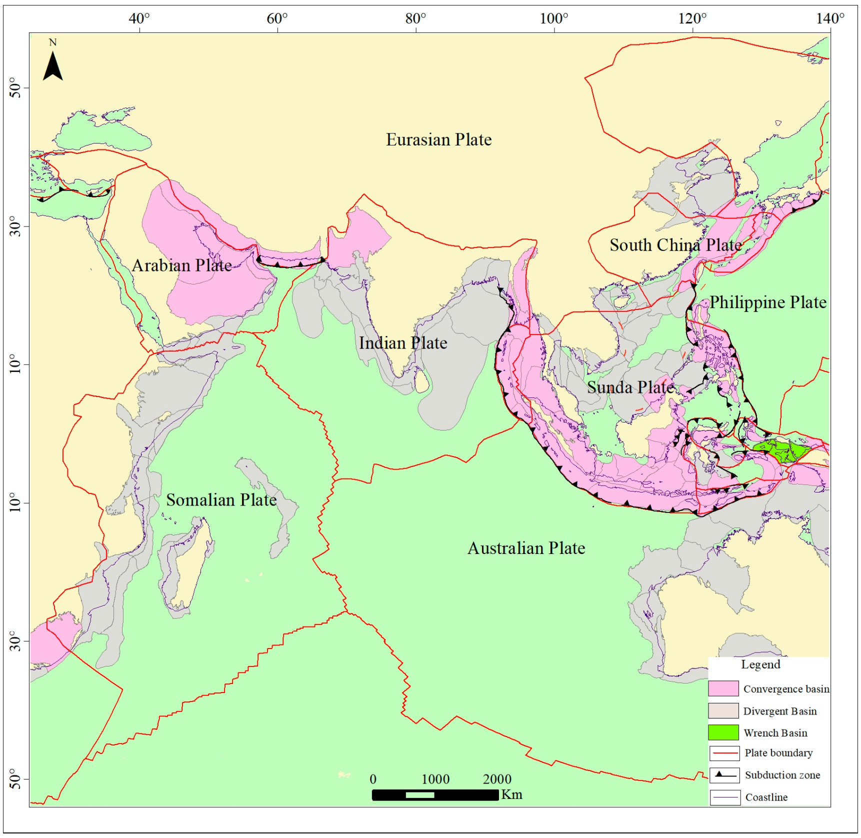

Figure 1. Simplified map of the coastal and peripheral continental structures along the Silk Road.

On the fringes of the Silk Road, passive continental margin basins are predominantly distributed along the eastern coastline of Africa, as well as the eastern and western coasts of India. Back-arc basins are primarily situated to the northeast of the Sunda-Java subduction zone, arising from the subduction of the Indo-Australian Plate beneath the Eurasian Plate. Forearc basins are most notably found to the southwest of Sumatra Island.

3. Characteristics of Hydrocarbon Resources along the Silk Road

3.1. Characteristics of Oil and Gas Resource Distribution along the Silk Road

The countries and regions spanning the Silk Road possess expansive territories abundant in marine mineral resources, with a pronounced emphasis on oil and gas. This area stands out not only as one of the world's foremost reservoirs of oil and gas but also as one of the most dynamic hubs for exploration and development on a global scale. The exploration status in oil- and gas-bearing basins within the Silk Road maritime zones indicates that the Bay of Bengal, the Neotethyan deepwater basin group, the Arabian Sea deepwater basin, the East African continental margin deepwater basin group, and certain segments of the deepwater basins in the Western Pacific exhibit relatively low exploration levels, resulting in fewer discoveries of oil and gas fields (Figure 2).

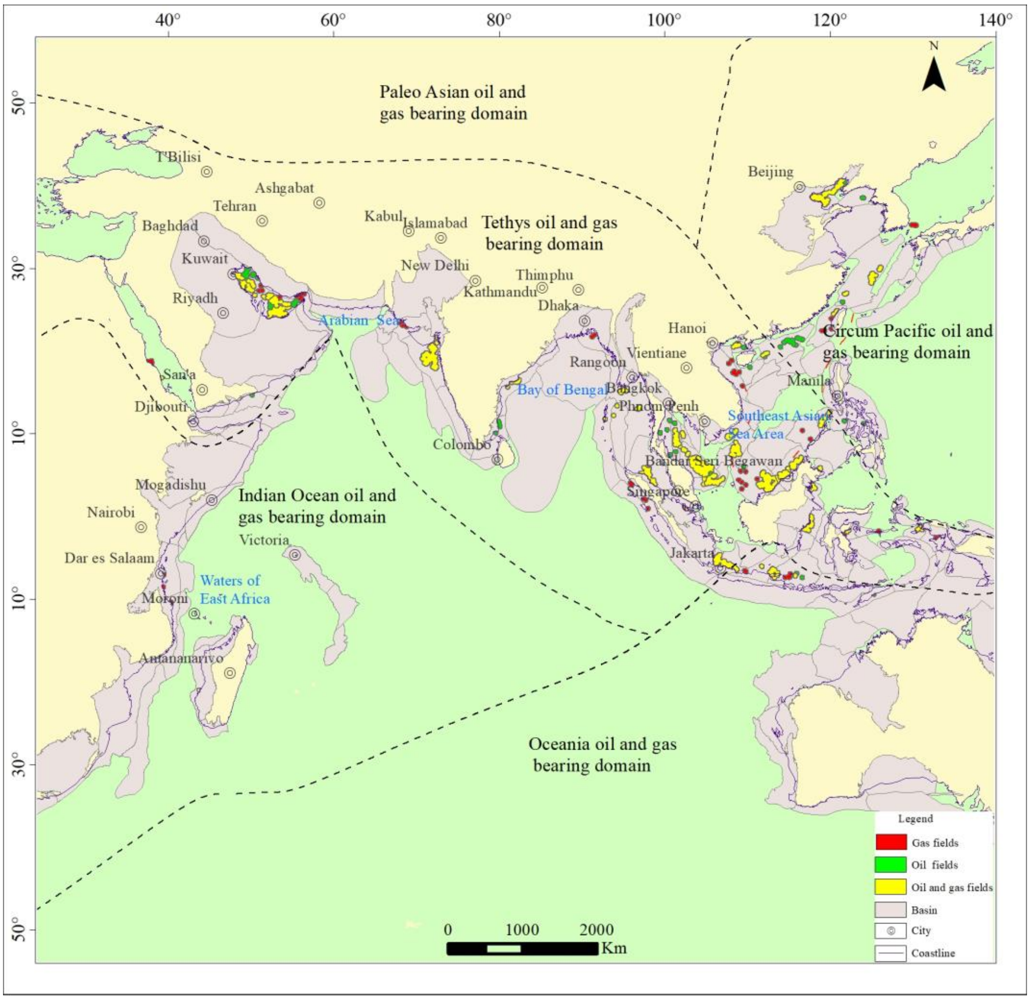

Figure 2. Distribution map of oil and gas resources along the Silk Road.

Approximately 163 basins are dispersed across both the maritime and terrestrial domains of the Silk Road countries (Appendix A). These basins predominantly lie within the oil- and gas-rich sectors of the Neotethyan and Indian Ocean domains. According to oil and gas reserve data from the US Geological Survey (USGS) and BP, the Silk Road region boasts proven reserves totaling 2.973 billion tons of oil equivalent, encompassing 1.722 billion tons of oil and 1.251 billion tons of natural gas equivalent (Table 1). Furthermore, prospective reserves amount to 986 million tons of oil equivalent, including 431 million tons of oil and 555 million tons of natural gas equivalent (Table 2). Along the Silk Road, there exist 128 oil and gas fields. These fields, in terms of the geological eras in which their reservoirs were formed, are primarily associated with the Mesozoic and Cenozoic epochs. Regarding the lithological composition of these reservoirs, they are predominantly composed of sandstone and carbonate rocks. As for trap types, structural traps represent the predominant category (Figure 3).

Table 1. Quantities of oil and gas resources in different Silk Road regions.

Resource Quantity (Billion Tons of Oil Equivalent)	Southeast Asia	South Asia	Arabian Region	East Africa
Proven Oil	58.58	11.75	1436.68	
Proven Natural Gas	87.33	15.44	832.92	37.78
Prospective Oil	52.72	5.31	126.52	31.23
Prospective Natural Gas	73.89	10.22	140.82	53.12

Table 2. Status of oil and gas basins in Silk Road countries.

Deepwater Oil and Gas Basin Group	Maritime Area	Major Basins	Existence of Underexplored Basins	Primary Involved Nations
Neotethyan Deepwater Basin Group	Southeast Asian Waters	Weber, North Sumatra, Salawati, Banda, Bali, Flores, Aru, Sulawesi, Willem-Poortman, Lombok, Savu, etc.	Yes	Indonesia, Malaysia, Brunei, Thailand, Cambodia, Vietnam, the Philippines, Papua New Guinea
	Bay of Bengal	Krishna-Godavari, Gave Ri, Rakhine, Bengal, Bay of Bengal Deep Sea Fan, etc.	Yes	India, Myanmar, Bangladesh
	Arabian Sea	Arabian Gulf Deepwater Basin	Yes	Pakistan, Oman, Iran, Saudi Arabia
East African Continental Margin Deepwater Basin Group	Western Indian Ocean Waters	Somalia, Lamu, Tanzania, Rovuma, Zambezi Delta, Murendwa, etc.	Yes	Somalia, Kenya, Tanzania, Mozambique, Madagascar

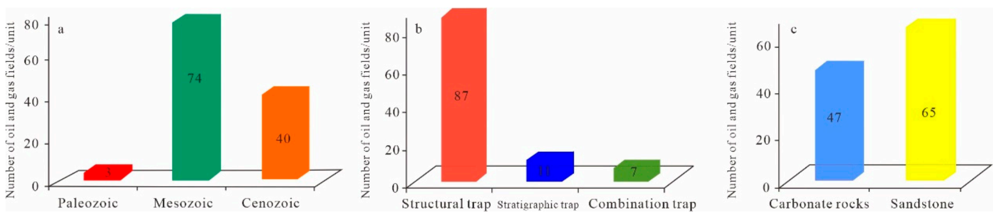

Figure 3. Characteristics of oil and gas fields along the Silk Road ((**a**) the geological age of the reservoir; (**b**) trap types of oil and gas fields; (**c**) the lithology of the reservoir).

The Bay of Bengal emerges as a promising locale for oil and gas resources in South Asia [29,30]. Since the 1990s, there has been a succession of discoveries of gas fields in the shallow waters of the Bay of Bengal. Recent years have witnessed intensified efforts by Bangladesh, Myanmar, and India in the realm of deepwater oil and gas exploration within the Bay of Bengal, yielding substantial breakthroughs. It is estimated that approximately 2.6 trillion cubic meters of natural gas reserves still remain within this region.

The distribution of oil and gas resources in Southeast Asian waters primarily centers on Thailand, Malaysia, and Indonesia [30,31]. Thailand's oil and gas resources are predominantly dominated by natural gas, primarily concentrated in the Gulf of Thailand basin. Currently, Thailand supports nearly 120 active oil and gas fields, with over half of them located offshore. Key fields, including the Benchams Oil Field, Plamuk Oil Field, Jasmine Oil Field, Arthit Gas Field, and Pailin Gas Field, are all situated within the Gulf of Thailand basin [32]. Malaysia's principal oil and gas areas encompass the Gulf of Thailand-Malay Basin, the Sarawak Basin, and the Sabah Basin. These regions hold undiscovered oil resources amounting to 480 million tons and untapped natural gas resources of 360.9 billion cubic meters. Indonesia, rich in oil and gas resources, features predominantly onshore oil reserves, while over 70% of its natural gas resources are situated offshore, primarily within the Natuna Sea and the East Kalimantan Sea. Additionally, the offshore region shared by Indonesia and East Timor equally boasts substantial oil and gas resources.

Since 2006, East Africa has achieved significant strides in the field of oil and gas exploration. To date, multiple favorable zones for oil and gas resources have been identified in coastal and deepwater areas [18,33,34]. Offshore oil and gas resources are principally concentrated in the waters proximate to Mozambique and Tanzania. Mozambique's territorial waters have revealed 13 gas fields with proven geological reserves totaling 5.3 trillion cubic meters and recoverable reserves of 4.1 trillion cubic meters. Tanzania, meanwhile, has approximately 50 offshore drilling sites, leading to the discovery of 21 gas fields with proven geological reserves of 1.35 trillion cubic meters and recoverable reserves of 104 million cubic meters [35,36].

3.2. Characteristics of Deepwater Oil and Gas Resources along the Silk Road

3.2.1. The Neotethyan Deepwater Basin Group

(1) The deepwater region of the Bay of Bengal

Situated in the eastern part of the Indian subcontinent, west of the Myanmar–Andaman–Sumatra region, and offshore in southern Bangladesh, the Bay of Bengal is an area rich in continental margin basins holding substantial reserves of oil and gas. These basins can be categorized into three groups based on tectonic positions and structural attributes. The first group comprises passive continental margin basins on the western side, including Mahanadi, Krishna-Godavari, Gavil Garh, Mumbai, Indus Fan, and Kutch basins. The second group encompasses active continental margin basins on the eastern side, such as Rakhine, Maday Island, Andaman, and North Sumatra basins. The third group constitutes the northern residual ocean basins, particularly the Bay of Bengal basin itself. Oil and gas exploration in the Bay of Bengal predominantly involves India, Myanmar, and Bangladesh. Currently, major exploration activities in this region are centered around onshore and shallow-water regions adjacent to these basins. Recent years have witnessed significant discoveries of deepwater natural gas in the Krishna-Godavari, Gavil Garh, and Rakhine basins, confirming the substantial potential for natural gas exploration in this area.

In the Bay of Bengal region, hydrocarbon source rocks primarily date back to the Paleogene and Cretaceous periods, followed by the Neogene [37]. These source rocks developed mainly in shallow marine and deltaic environments. Shallow marine source rocks are concentrated in the Gavil Garh basin, while deltaic source rocks are widespread and predominantly composed of coal and carbonaceous shale. These source rocks are found along the peripheries of the Indian subcontinent, notably in the Paleocene to Early Eocene deltaic shale in the Bay of Bengal basin. With the exception of limestone, found in the interior of the Indian subcontinent, most basins are predominantly composed of shale and occasionally interspersed with coal-bearing strata (Table 3). The sedimentary environments in the Bay of Bengal region predominantly include nearshore, deltaic, and fluvial settings. During the rifting phase, alluvial fans, fluvial, and deltaic sandstone deposits were prominent. Subsequently, in the post-rift phase, shallow marine, deltaic, and deep fan sandstones, as well as extensive carbonate rocks, became prevalent. The primary cap rocks are of Neogene origin, followed by those from the Mesozoic. Shale is the dominant lithology, with coal beds and compact carbonates being the secondary components [38,39].

Table 3. Notable oil and gas discoveries in the deepwater region of the Bay of Bengal [9,12].

Well Name/Oil and Gas Field Name	Discovery Year	Country	Basin	Water Depth/m
Dhirubhai	2002	India	Krishna-Godavari	2000~3000
Well CY-III-D5-A1	2007	India	Gavil Garh	1185
R1 Gas Field	2012	India	Krishna-Godavari	Deepwater
Well CY-III-D5-S1	2013	India	Gavil Garh	1743
Well KG-DWN-98/2-m-4	2015	India	Krishna-Godavari	Deepwater
Shwe Yee Htun-1 Gas Field	2016	Myanmar	Rakhine	Deepwater
Thalin-1A Gas Field	2016	Myanmar	Rakhine	836

(2) Deepwater regions of Southeast Asia

The deepwater regions of Southeast Asia are renowned for their abundant oil and gas resources, constituting approximately 17% of the world's deepwater reserves. While the overall exploration activities in these deepwater areas are relatively active, the depth of exploration remains modest. Recent years have witnessed a surge in offshore oil and gas exploration, leading to the discovery of multiple deepwater oil and gas fields across various basins and deepwater blocks in the Southeast Asian region, including Brunei-Sabah, Palawan, Zengmu, and Kutai. These discoveries underscore the considerable exploration potential within these deepwater zones.

Situated at the convergence of the Eurasian, Indo-Australian, and Pacific tectonic plates, Southeast Asia has undergone a complex geological evolution marked by plate collisions, amalgamations, and an array of geological processes. This dynamic history has given rise to diverse sedimentary basins, comprising active continental margin basins, cratonic basins, passive continental margin basins, and foreland basins. Among the more than 100 sedimentary basins in Southeast Asia, 47 have successfully uncovered oil and gas resources, rendering the region exceptionally rich in oil and gas. It is worth noting that there are over 400 established Paleogene oil and gas fields, estimated to hold approximately 1.195 billion tons of resources. Furthermore, there are in excess of 1500 recognized Neogene oil and gas fields, collectively hosting around 12.024 billion tons of resources [40]. The most recent data reveal a substantial number of deepwater oil and gas fields within close proximity to Kalimantan Island, underscoring the enormous exploration potential in Southeast Asia's deepwater domains (Table 4). In the offshore basins of Southeast Asia, hydrocarbon source rocks primarily consist of Cenozoic deltaic coal and carbonaceous shale, as well as lacustrine and marine shale. These source rocks predominantly date back to the Eocene, Oligocene, and Middle Miocene. The reservoirs are primarily composed of Cenozoic deep-sea turbidite sandstones. These deepwater regions are poised to become the principal focal points for oil and gas exploration and production in Southeast Asian nations.

Table 4. Significant oil and gas discoveries in the deepwater areas of Southeast Asia [9,12].

Well Name/Oil and Gas Field Name	Discovery Year	Country	Basin/Block	Water Depth/m
Well GT-1X	2011	Vietnam	MeoTrang Oil Field	Deepwater
TiungBiru Oil Field	2012	Indonesia	East Java Province-Gunung Geulis Block	Deepwater
Well NC8SW-1	2012	Malaysia	Sabah Island SK317 Block	Deepwater
Exploration Well No. 3	2013	Vietnam	05-1b and 05-1c Offshore Blocks	Deepwater
Well Marjoram-1	2014	Malaysia	Sarawak State Offshore SK318 Block	1000
Sturgeon Oil Field	2015	Vietnam	09/3-12 Offshore Block	Deepwater

(3) The deepwater region of the Arabian Sea

The Indus Fan stands as the world's second-largest deep-sea fan, situated within Pakistan's exclusive economic zone in the Arabian Sea. The exploration focus extends to the upper Indus Fan, and the adjoining shallow-water continental shelf area has captured significant attention. To date, 14 wells have been drilled in the nearshore basin of the Indus Fan. Regrettably, only one, Well Pakcan-1, encountered natural gas within the continental shelf area [41]; however, it did not meet industrial production standards. Well-core tests reveal that the Upper to Middle Miocene shales serve as excellent to very good source rocks in this region, exhibiting an approximate thickness of 300 m and an average total organic carbon (TOC) content of 2%. It is hypothesized that potential source rocks in the Indus Fan area primarily belong to the Cretaceous and Paleogene shales, predominantly characterized by Type III organic matter, spanning from maturation to over-maturation [42]. The reservoir predominantly consists of Miocene sandstones and Paleocene reef limestone or shoal limestone (Figure 4). Among these, the Miocene sandstones, encountered in Well PakCan-1, range from 2 to 50 m in thickness with porosities between 15% and 20%. The reef limestone and shoal limestones from the Paleocene to Eocene, discovered in Well PaK-G2-1, exhibit porosities exceeding 20% [43]. While the entire region lacks a continuous shale cap rock, the localized development of shale cap rocks is evident, particularly in the thick upper segments of the Middle Miocene shale layers. These cap rocks are widely distributed and can serve as regional cap rocks. The latest seismic data interpretation suggests that the nearshore basin of the Indus Fan features multiple source rocks, with both Miocene fluvial sand in the continental shelf area and Eocene reef limestone in the deepwater region being prevalent, indicating excellent reservoir quality and promising prospects for oil and gas exploration in the deepwater areas (Figure 5).

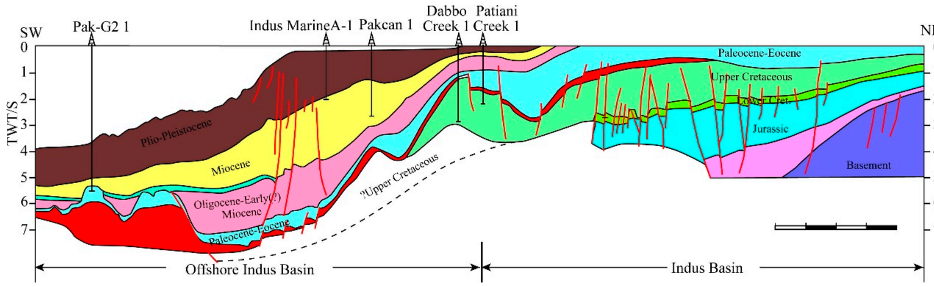

Figure 4. Geoseismic section from onshore Lower Indus to deep offshore Indus [43].

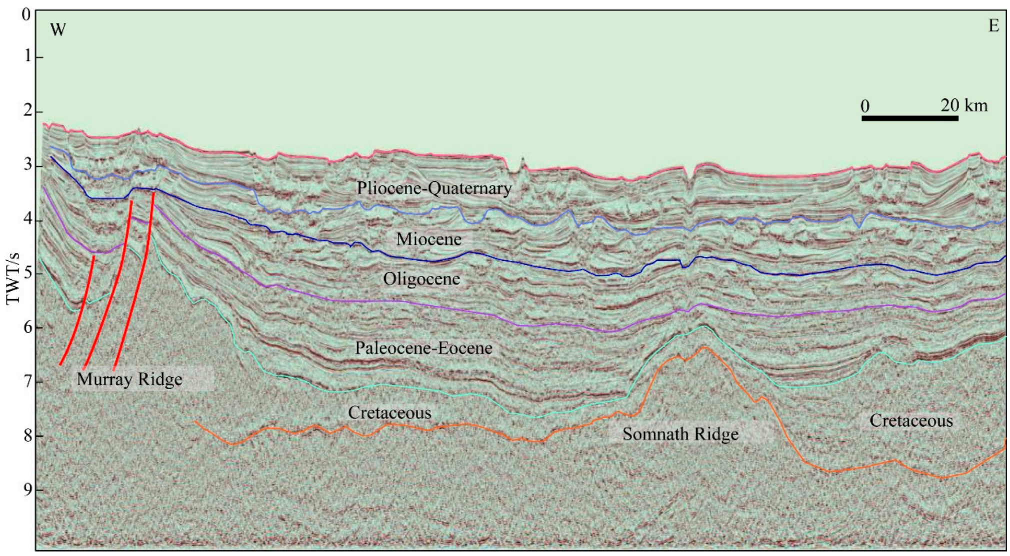

Figure 5. Seismic profile of the Indian fan offshore basin [41].

3.2.2. Deepwater Basin Groups along the East African Continental Margin

In recent years, the deepwater regions of East Africa have witnessed remarkable advancements compared to North and West Africa, marked by the discovery of world-class deepwater gas fields in basins such as Rovuma and Tanzania. Despite oil and gas exploration efforts commencing in the 1950s, limited activities and a lack of exploration wells hindered significant discoveries until the 1990s. Before then, only small-scale oil and gas reservoirs were identified. By 2010, a total of 232 wells had been drilled, mainly in onshore and shallow-water areas (less than 100 m in depth), with minimal success. Seven small to medium-sized commercial natural gas fields were found in onshore and shallow-water areas, spanning Somalia, Mozambique Coastal Basin, Tanzania, and the Rovuma Basin [35,43,44]. A turning point occurred in 2010 with the discovery of 12 substantial gas fields in the deepwater areas of East Africa, at an average depth of approximately 1650 m, resulting in a cumulative proven reserve of 2.7 trillion cubic meters [44]. This has positioned the region as a focal point for global oil and gas exploration activities in recent years and stands as a pivotal domain for deepwater oil and gas exploration, as evidenced by two of the top ten global oil and gas exploration discoveries in 2011 and seven in 2012 emerging from East Africa (Table 5).

Table 5. Recent discoveries in oil and gas exploration in the deepwater regions of the East African coast.

Oil and Gas Field Name	Discovery Date	Country	Basin	Water Depth/m	Type	Proven Reserves (Billion Tons of Oil Equivalent)
Pweza 1	16 October 2010	Tanzania	Mafia Deep	1400	Gas	0.48
Prosperidade Complex	19 October 2010	Mozambique	Rovuma	1585	Oil, Gas	7.45
Chewa 1	30 November 2010	Tanzania	Mafia Deep	1315	Gas	0.34
Tubarao 1	15 February 2011	Mozambique	Rovuma	866	Gas	0.22
Chaza 1	15 April 2011	Tanzania	Rovuma	952	Gas	0.01
Mamba Complex	15 October 2011	Mozambique	Rovuma	1320	Oil, Gas	11.54
Zafarani 1	17 February 2012	Tanzania	Mafia Deep	2582	Gas	0.92
Jodari 1	15 March 2012	Tanzania	Rovuma	1295	Gas	0.95
Golfinho/Atum	15 May 2012	Mozambique	Rovuma	1027	Gas	6.59
Mzia 1	15 May 2012	Tanzania	Rovuma	1639	Gas	1.21
Coral 1	15 May 2012	Mozambique	Rovuma	2261	Oil, Gas	2.77
Papa 1	4 June 2012	Tanzania	Mafia Deep	2186	Gas	0.15
Lavani 1	13 June 2012	Tanzania	Mafia Deep	2400	Gas	0.88
Orca 1	18 April 2013	Mozambique	Rovuma	1061	Gas	0.25
Agulha 1	2013	Mozambique	Rovuma	2492	Gas	1.05
Tangawizi 1	28 March 2013	Tanzania	Mafia Deep	2300	Gas	0.88
Ngisi 1	28 March 2013	Tanzania	Mafia Deep	1250	Gas	0.30
Mronge 1	1 December 2013	Tanzania	Mafia Deep	2500	Gas	0.45
Taachui 1	26 June 2014	Tanzania	Tanzania	609	Gas	0.23
Piri 1	18 June 2014	Tanzania	Mafia Deep	2360	Gas	0.44
Giligiliani 1	14 October 2014	Tanzania	Mafia Deep	2500	Gas	0.21
Kamba 1	2 October 2014	Tanzania	Mafia Deep	1379	Gas	0.15
Mdalasini 1	30 March 2015	Tanzania	Ruvuma	2296	Gas	0.25

At present, petroleum reservoirs discovered along the East African coast are predominantly natural gas, concentrated in the northern segment. In contrast, Madagascar focuses primarily on heavy oil and oil sands, mirroring the structural attributes of the northern region [45,46]. Major gas fields identified in the Rovuma and Tanzania basins are situated in the deepwater areas west of the Davie Fault Zone (DFZ). Specifically, in the Rovuma Basin, major gas fields are chiefly located within the offshore thrust fault zone and its foreland, with no significant gas fields identified in the nearby normal fault development zone. In the Tanzania Basin, major gas fields are distributed along the north–south direction of normal fault lines (Figure 6).

The East African coast is characterized by two sets of effective source rocks spanning from the Carboniferous to the Lower Jurassic and from the Middle to Upper Jurassic through to the Cretaceous [43,47]. The Carboniferous to Lower Jurassic source rocks consist mainly of continental shale and coal series, featuring mainly type II-III kerogen types with a maximum thickness of nearly one hundred meters. These source rocks, primarily found in the eastern sectors of the Somali Basin, central areas of the Lamu Basin, Tanzania Basin, Rovuma Basin, and eastern extents of the Mlindiwa Basin, are highly evolved and generally mature or over-mature, contributing primarily to gas. Notably, Nondwa evaporites and Mbuo shales of the Lower Jurassic serve as exceptional source rocks in the Tanzania Basin. Meanwhile, the Middle to Upper Jurassic and Cretaceous source rocks exhibit widespread distribution and are characterized by high-quality attributes. Among these, the Tanzania, Rovuma, and Somalia basins exhibit the most favorable source rock conditions. The primary source rocks in this context are the Bajocian shales of the Middle to Upper Jurassic and the black shales of the Campanian stage in the Upper Cretaceous.

Multiple sets of reservoirs have developed within the sedimentary basins of the African East Coast. Reservoirs from the Permo-Triassic to the Neogene showcase robust petrophysical properties [48]. In addition to the Karoo Group continental clastic rock reservoirs, the other primary reservoirs comprise Middle to Upper Jurassic clastic rocks, Cretaceous to Neogene marine clastic rocks, and carbonates. Clastic rock reservoirs predominantly consist of deltaic and nearshore turbidite sandstones, while carbonate reservoirs primarily comprise biogenic reefs or clastic limestone, shallow marine limestone, post-reef oolitic limestone, and shelf carbonate rocks.

Cap rocks within the sedimentary basins of the East African coast predominantly consist of shale, mudstone, and marl. Notably, the Somali Basin, Tanzania Basin, Mlindiwa Basin, and Rovuma Basin feature substantial layers of evaporites, which serve as crucial cap rocks [49].

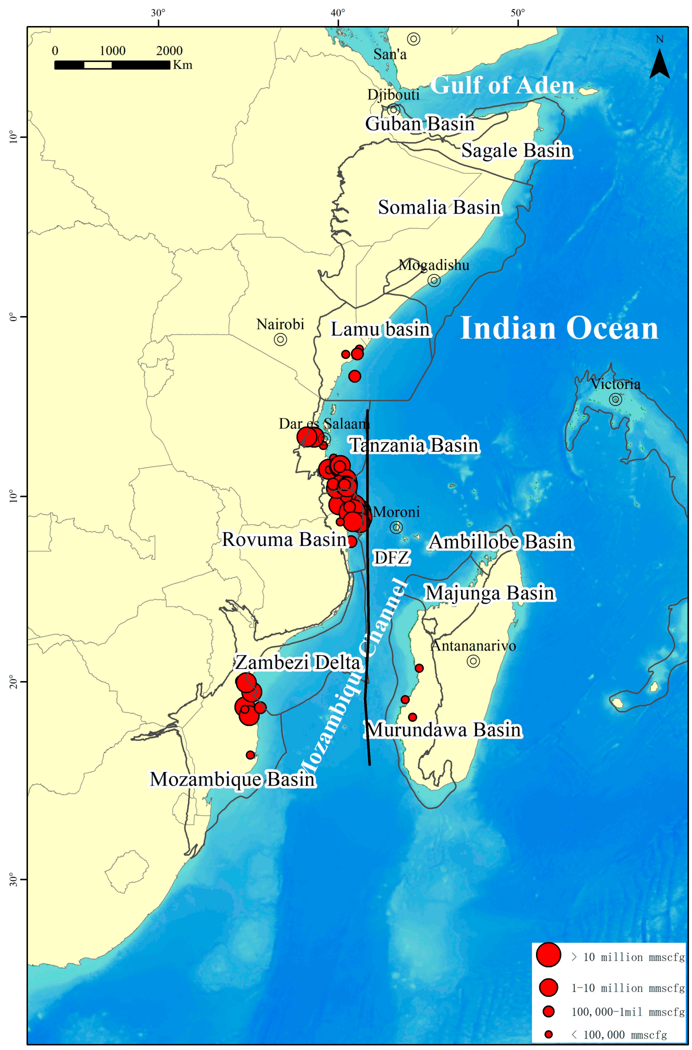

Figure 6. Distribution map of oil and gas fields along the East African coast [50].

4. Geological Characteristics of Deepwater Basin Groups along the Silk Road

The deepwater basin groups along the Silk Road exhibit a predominant "horizontal and vertical" distribution (Figure 7). The "horizontal" distribution primarily corresponds to east–west-oriented deepwater basin belts within the Neotethyan tectonic domain, situated along passive continental margins. These areas initially experienced extension during the passive continental margin phase and later underwent compression due to collisional mountain-building processes. Included in this category are the deepwater basins of the northern continental margin of the South China Sea, the Zengmu Basin, the Brunei-Sabah Basin in the southern South China Sea, the deepwater basins within the Gulf of Myanmar, the deepwater basins of the Bay of Bengal, and the deepwater basins within the Arabian Gulf. The "vertical" distribution primarily pertains to the north–south-oriented East African continental margin deepwater basin groups, characterized as typical passive continental margin basins in an extensional setting, including the Somalia Basin, Rovuma Basin, Tanzania Basin, and Mozambique Basin.

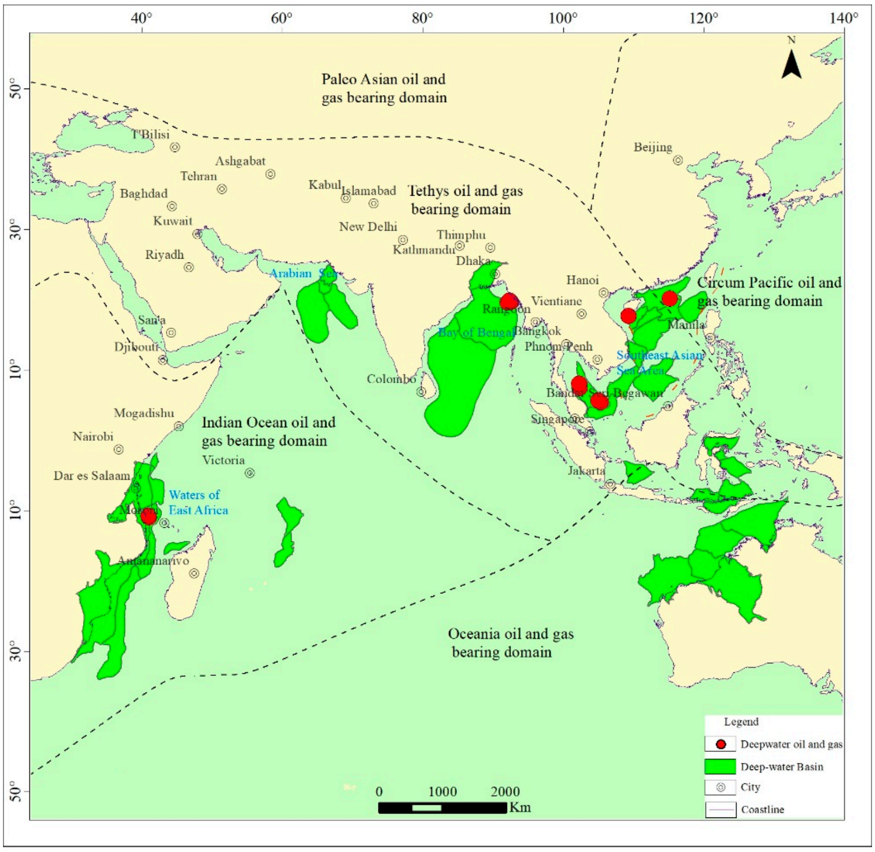

Figure 7. Distribution of deepwater basins along the Silk Road.

4.1. Geological Characteristics of Deepwater Basin Groups in the Neotethyan Tectonic Domain

The Tethys tectonic domain, an east–west-oriented oceanic trench that separated the Laurasia and Gondwana supercontinents from the Early Paleozoic to the Late Cretaceous [36,51,52], played a crucial role in shaping the deepwater basin groups within the Neotethyan tectonic domain. The Tethys Ocean's formation was initiated during the Late Permian period, marking the initial rift in the eastern Gondwana continent. It evolved into a mid-Mesozoic oceanic basin [53,54], situated between the Cimmerian continent(s) and the eastern Gondwana continent. The Jurassic period witnessed the substantial expansion of the Tethys Ocean, fostering the development of intraplate basins and passive continental margin sedimentation. Subsequently, during the Cretaceous period, the subduction of the Tethys Ocean beneath the Eurasian Plate commenced, transforming its northern margin into an active continental margin during the Late Cretaceous. The Early to Middle Eocene period saw the gradual closure of the Tethys Ocean due to the rapid collision between the Indian Plate and the Eurasian Plate. This collision displaced fragments, such as the Sunda Block and the Indochina Block southeastward, giving rise to Neogene arc–forearc basins and back-arc rift basins.

In Southeast Asia, as an illustrative case, there were three distinct phases of structural evolution: rifting, thermal subsidence, and inversion [55]. During the Early Neogene to Early Miocene, the region primarily underwent the rift development phase, marked by prevalent fluvial and lacustrine clastic sedimentation. By the Late Miocene, a notable marine transgression took place, transitioning from terrestrial to marine sedimentary environments, resulting in the deposition of extensive shallow marine mudstone and carbonate sediments. In the Late Middle Miocene, the subduction of the young oceanic crust under the continental margin induced regional compression and strike-slip events, often accompanied by repeated sea-level fluctuations. These processes contributed to the development of extensive delta-front and submarine fan sedimentation.

4.2. Geological Characteristics of Deepwater Basin Groups in the East African Continental Margin

The East African passive continental margin basin groups, shaped by geological processes, including the rifting of the eastern Gondwana continent and the Indian Ocean expansion, underwent three principal phases of structural evolution, resulting in a dual-layer structure known as "lower faulted-upper tilted" [44,47]. The rift phase commenced in the Early Carboniferous period marked the onset of the rift phase, as the Karoo mantle plume became active in the eastern Gondwana continent, causing crustal uplift, intense faulting, and volcanic activity. This phase led to the formation of rift-type grabens [56], primarily filled with terrestrial fluvial, lacustrine, and coal-bearing sediments. During the Middle Jurassic period, the rift extended from northwest to southeast within the Gondwana continent, resulting in significant subsidence in regions like modern-day Somalia, Tanzania, and Madagascar. Additionally, a substantial marine transgression occurred, establishing a system of continental shelf carbonate platforms [57] and transitioning the environment from fluvial and lacustrine to marine sedimentary environments. In the southern region, the Mozambique Basin, located on the margin of the Karoo Basin, experienced intense volcanic activity and the deposition of abundant volcanic rocks [49]. During the Late Jurassic to Early Cretaceous, as drifting continued, the eastern Gondwana continent moved southward, and the ocean floor continued to expand. The connection of the northern and southern Indian Oceans resulted in rising sea levels, contributing to the development of widespread marine sedimentary environments, which overlay the underlying rift sedimentary layers [48]. By the Late Cretaceous, the region entered a passive continental margin phase marked by robust volcanic activity and a substantial supply of coarse clastic materials. During the Paleogene and Neogene periods, as global sea levels fluctuated, the region featured diverse sedimentary environments, including lagoon, intertidal, supratidal, shallow marine carbonate platform, nearshore turbidite, and deep-marine deposits.

5. Controlling Factors and Exploration Potential

5.1. Substrate for Deepwater Gas Field Formation

In deepwater environments, a variety of source rocks hold the potential to yield oil and gas. Oil source rocks encompass lacustrine, open-marine, and dispersed organic materials. Gas sources encompass dispersed organic materials generating both biogenic and thermogenic gas, originating from source rocks surpassing the oil generation threshold. Notably, world-class oil and gas fields are present in the Jurassic, Cretaceous, and Paleogene strata (Figure 8).

The Silk Road region exhibits a sequence of continental rifts and passive continental margin basin groups formed during the fragmentation of the Gondwana Plate and the initiation of new plate tectonics. Having evolved through successive structural and sedimentary alterations, these basins provide favorable conditions for petroleum geology and diverse accumulation scenarios. Hydrocarbon source rocks are predominantly distributed in Mesozoic and Cenozoic strata, appearing in various types, such as platform-to-basin carbonates (predominantly marl), dark mudstones, carbonaceous mudstones, carbonaceous shales, and coal, often within littoral and transitional marine settings. Reservoirs primarily fall into two categories: carbonate rocks and clastic rocks. Carbonate rock reservoirs consist mainly of dolomitic limestone found within shallow marine carbonate platforms, delta fronts, and deep-sea shelf environments. Clastic rock reservoirs, on the other hand, are primarily composed of distributary channel sandstones, beach sandstones, and deepwater fan sandstones located in delta and shoreface depositional systems. These sandstones exhibit well-developed sorting and roundness, possessing a high degree of structural and compositional maturity. Cap rocks are predominantly composed of deep-sea mudstones. Mesozoic and Cenozoic deepwater basins, subjected to multiple phases of tectonic activity, have created various trap types, including uplifts, rollover anticlines, large gravity structures, and tilted fault blocks, all exhibiting strong hereditary characteristics. Currently, deepwater regions globally are in the early stages of exploration, characterized by limited drilling activity, promising a high potential and a high likelihood of discovering significant oil and gas accumulations. Ongoing exploration efforts focus on confirmed hydrocarbon-rich basins and newly established basins. Large structural-type oil and gas fields remain dominant, with numerous substantial structural traps yet to be drilled. These traps encompass various types associated with gravitational detachment structures and tilted fault blocks structures, especially ultra-deepwater and deep-seated traps and those characterized by complex structural and lithological settings.

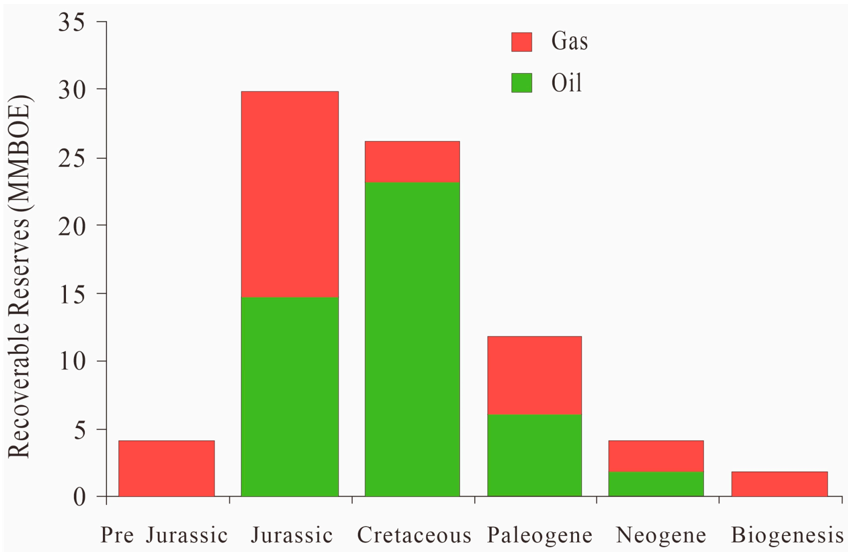

Figure 8. Relationship between deepwater recoverable reserves and hydrocarbon source rock ages.

5.2. Efficient Systems for Oil and Gas Migration

In deepwater regions, oil and gas migration is observed to manifest through various methods, including long-distance and short-distance transport. Following hydrocarbon generation in source rocks, an efficient migration system transports them to suitable traps for accumulation. Faults, salt tectonics, and sand bodies act as efficient conduits for oil and gas migration [9,58].

The concentration of oil and gas in the Bay of Bengal correlates closely with the distribution of large rivers and deltas. Primary reservoir combinations in the Middle Miocene of the North Sumatra Basin are associated with marine deltaic depositional environments. After hydrocarbon generation, migration occurs through interconnected sand bodies, fault surfaces, and mud diapirism, resulting in their accumulation within large river-delta and deepwater turbidite fan deposits. These accumulations are notably focused within lithological and structural traps, as well as rollover anticlinal traps.

In the deep-sea regions of the East African continental margin, faults significantly control the formation of oil and gas accumulations, providing crucial migration pathways. Major oil and gas fields are predominantly distributed on both sides of the Davie Fault Zone (DFZ), characterized by interconnected faults linking source rocks. The practices of global deepwater oil and gas exploration highlight that anticlines within deepwater fold–thrust belts, particularly those masked by reverse faults on one side, represent the most probable structural traps for the discovery of industrial oil and gas [59,60]. The Mamba gas field, discovered in the Rovuma Basin, is situated on the eastern leading edge of the reverse thrust within the deepwater fold–thrust belt. As a result of reverse fault activity, numerous fault-related anticlinal rollovers have developed in the upper section of the reverse fault, establishing excellent structural traps [61,62]. Additionally, the region features extensive deepwater turbidite fans with well-connected sand bodies and favorable reservoir properties, making it an efficient, high-quality reservoir. Early oil and gas, primarily gaseous, generated from marine source rocks, migrated along eastern faults connecting source rocks and filled the Paleogene sand bodies, forming lithological and structural oil and gas traps [48].

A large amount of oil and gas has been discovered in the Ruvuma Basin and the Tanzania Basin in East Africa, as well as in the Rakhine Basin in Myanmar [14,63]. The reservoir is mainly composed of river-channel and turbidite sandstones, shaped through the combined effects of gravity flow and bottom flow. Deepwater sedimentary bodies are mutually eroded, laterally migrated, and vertically stacked, exhibiting complex spatiotemporal relationships. They are formed by the migration and stacking of sedimentary units from distinct periods, showcasing complex vertical changes and strong heterogeneity. For instance, the Paleogene reservoirs in the Luwuma Basin of East Africa are mainly composed of channel and cluster sedimentation [63,64]. Due to the simultaneous influence of bottom flow during sedimentation, turbidite sand bodies in this area have evolved into high-quality reservoirs with pure sand and favorable petrophysical properties. The lateral migration and vertical stacking of channels and clusters have contributed to the substantial scale and thickness of sand bodies, creating optimal reservoir conditions.

5.3. Exploration Prospects

To date, the deepwater regions along the Silk Road have yielded numerous oil and gas discoveries. Deepwater exploration activities in Southeast Asian waters have been highly active, resulting in 17 significant discoveries, primarily concentrated in countries such as Malaysia, Indonesia, China, and Vietnam. In East African waters, there have been 23 discoveries, including 7 in Mozambique and 16 in Tanzania, with an estimated resource quantity of 3.772 billion tons of oil equivalent. India and Myanmar have also identified several deepwater natural gas deposits in the Bay of Bengal, accounting for six oil and gas discoveries. Disparities in oil and gas discoveries, resource potential, exploration levels, and research are evident among the deepwater basins along the Silk Road (Figure 9). Currently, the major oil and gas fields found are predominantly of the structural trap type (Figure 9), leaving numerous unexplored complex traps, lithological traps, and structural traps in deepwater areas that await drilling. Abundant resources with immense potential characterize the deepwater oil and gas deposits along the Silk Road. A comparative analysis of the geological conditions and resource potential suggests that the overall exploration levels in deepwater areas are relatively low, presenting substantial opportunities for discovering large and giant oil and gas fields. Many exploration targets exhibit significant promise and warrant further investigation.

In the nearshore areas of the Bay of Bengal, the exploration level for oil and gas is relatively high, but the deepwater region offers promising prospects. The Bay of Bengal, forming a vast river-delta system, gives rise to various types of continental margin basins with substantial organic matter input along the continental margin. The conditions for hydrocarbon accumulation are exceptional, particularly in the deep-sea regions where Neogene turbidite sandstones extend. The primary exploration goal is to identify lithological traps. In the eastern seabed of Pakistan's waters, material primarily originates from the Indus River, resulting in the widespread distribution of Miocene river-channel sandstones and Eocene reef limestones in deepwater regions. These areas boast high-quality reservoirs and promising prospects for oil and gas exploration, with an emphasis on identifying lithological traps [41]. Southeast Asian waters, situated at the convergence of three major tectonic plates, have undergone complex tectonic evolution, resulting in various basin types. Hydrocarbon resources are concentrated in Cenozoic back-arc basins, rift basins, passive margin basins, and foreland basins. In the deepwater region of Southeast Asia, numerous thrust–fold belts have developed, prominently featuring structural traps. The conditions for hydrocarbon accumulation are excellent, with the primary objective being the identification of large structural-type oil and gas fields.

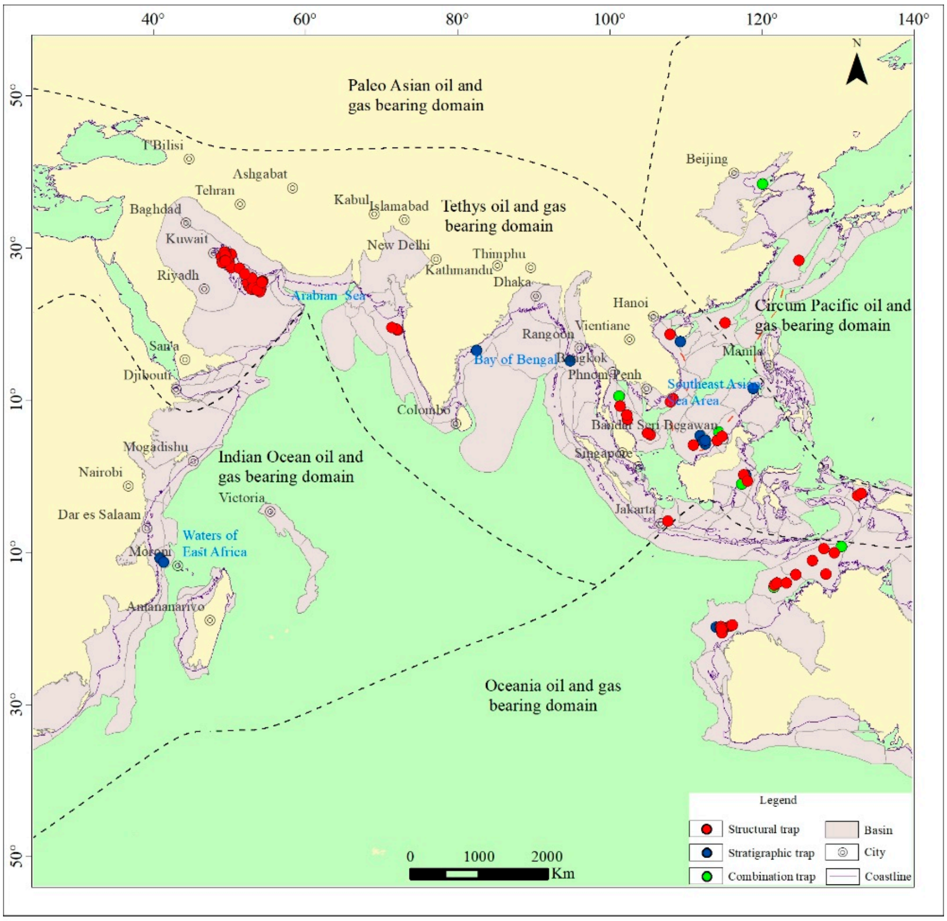

Figure 9. Main types of oil and gas traps along the Silk Road.

East African waters exhibit typical passive continental margin basins characterized by abundant petroleum geological conditions, multiple sets of source rocks, favorable cap rock and reservoir combinations, and well-developed structural and lithological traps. Current drilling results suggest that the favorable direction for exploration in the deepwater region off the East African coast should focus on lithological traps formed by the development of Neogene biogenic reefs and seafloor turbidite sandstones.

6. Conclusions

The principal deepwater oil and gas basins along the Silk Road exhibit a distinct "horizontal and vertical" distribution pattern. This primarily includes deepwater basin groups along the East African continental margin, the Western Pacific region, the Bay of Bengal in the Neotethyan region, and the deepwater basins of the Arabian Gulf. The oil and gas resources along the Silk Road hold tremendous potential, with the Arabian Sea being the primary focus, followed by Southeast Asia and East Africa. These resources are mainly distributed in the Middle to Late Cenozoic, primarily in structural traps, featuring carbonate rocks and sandstones as primary reservoirs. Looking toward the future, deepwater areas are poised to become the primary regions for augmenting oil and gas reserves and production in Southeast Asian nations. Within the Neotethyan region, the Bay of Bengal and the Pakistani waters hold promising prospects for deepwater basin natural gas exploration, while East Africa emerges as a global hotspot for natural gas exploration.

The deepwater basins along the Silk Road lay the material groundwork for significant oil and gas fields. Source rocks primarily consist of lacustrine, coal-bearing, and marine shales. Various reservoir types, notably deep-sea turbidite rocks and biogenic reefs, take center stage. These regions boast well-developed cap rocks and efficient oil and gas migration pathways. In the deepwater expanses of the Bay of Bengal, the primary emphasis is on lithological traps formed by Neogene turbidite sandstones. In the deepwater regions off Pakistan, the focus shifts to lithological traps formed by Neogene biogenic reefs and river-channel sandstones. In Southeast Asian deepwater areas, the primary objective is to unearth large structural-type oil and gas fields. Along the East African coast in deepwater regions, exploration efforts should concentrate on lithological traps formed by the development of Neogene biogenic reefs and seafloor turbidite sandstones.

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Data Availability Statement: All the data and materials used in this paper are available from the corresponding authors upon request.

Conflicts of Interest: The authors declare that there are no competing financial interests with any other people or groups regarding the publication of this manuscript.

Appendix A. Characteristics of Basins along the Silk Road

Fid	Basin Name	Basin Location	Exploration Status	Offshore Location	Basin Type
1	Great Australian Bight	Australia South Coast	Little Explored	Offshore	Divergent Basin
2	Mozambique Channel Ultradeep	East Africa	Unexplored	Offshore	Divergent Basin
3	Lamu Embayment Ultradeep	East Africa	Unexplored	Offshore	Divergent Basin
4	Majunga Ultradeep	East Africa	Unexplored	Offshore	Divergent Basin
5	Rovuma Ultradeep	East Africa	Unexplored	Offshore	Divergent Basin
6	Tanzanian Coastal Ultradeep	East Africa	Unexplored	Offshore	Divergent Basin
7	Tomori	Eastern Indonesia	Partially Explored	Offshore	Divergent Basin
8	Tukang Besi	Eastern Indonesia	Unexplored	Offshore	Convergent (Ocean–Continent) Basin
9	Salabanga Manui	Eastern Indonesia	Little Explored	Offshore	Divergent Basin
10	Flores	Eastern Indonesia	Little Explored	Offshore	Convergent (Ocean–Continent) Basin
11	Savu	Eastern Indonesia	Little Explored	Offshore	Convergent (Ocean–Ocean) Basin
12	Gorontalo	Eastern Indonesia	Unexplored	Offshore	Convergent (Ocean–Continent) Basin
13	Saya De Malha Bank	India and the Seychelles	Unexplored	Offshore	Divergent Basin

Fid	Basin Name	Basin Location	Exploration Status	Offshore Location	Basin Type
14	Offshore Indus Ultradeep	India and the Seychelles	Little Explored	Offshore	Divergent Basin
15	Indian Ocean Abyssal	India and the Seychelles	Unexplored	Offshore	Divergent Basin
16	Kachchh-Mumbai Ultradeep	India and the Seychelles	Little Explored	Offshore	Divergent Basin
17	Mumbai-Konkan Ultradeep	India and the Seychelles	Unexplored	Offshore	Divergent Basin
18	Mannar Ultradeep	India and the Seychelles	Unexplored	Offshore	Divergent Basin
19	Outer Bengal Fan	India and the Seychelles	Unexplored	Offshore	Divergent Basin
20	Nazareth Bank	India and the Seychelles	Unexplored	Offshore	Divergent Basin
21	Dangerous Grounds	Indo-China	Little Explored	Offshore	Divergent Basin
22	Malay	Indo-China	Well Explored	Offshore	Divergent Basin
23	Phu Khanh	Indo-China	Little Explored	Offshore	Divergent Basin
24	Nam Con Son	Indo-China	Partially Explored	Offshore	Divergent Basin
25	West Natuna-Penyu	Indo-China	Well Explored	Offshore	Divergent Basin
26	Khmer	Indo-China	Little Explored	Offshore	Divergent Basin
27	Browse	Northwest Australia	Partially Explored	Offshore	Divergent Basin
28	Tokara	Pacific Far East	Unknown	Offshore	Convergent (Ocean–Ocean) Basin
29	Nendo	Pacific Southwest	Unknown	Offshore	Convergent (Ocean–Ocean) Basin
30	East China Sea	Southeast China	Little Explored	Offshore	Convergent (Ocean–Continent) Basin
31	Qiongdongnan	Southeast China	Partially Explored	Offshore	Divergent Basin
32	Xisha	Southeast China	Unexplored	Offshore	Divergent Basin
33	Zhongsha Plateau	Southeast China	Little Explored	Offshore	Divergent Basin
34	Shuangfeng	Southeast China	Unknown	Offshore	Divergent Basin
35	Bijia	Southeast China	Unknown	Offshore	Divergent Basin
36	Andaman Sea	Western Indonesia	Unknown	Offshore	Convergent (Ocean–Continent) Basin
37	Biliton	Western Indonesia	Little Explored	Offshore	Convergent (Ocean–Continent) Basin
38	Gippsland	Australia South Coast	Well Explored	Onshore and Offshore	Divergent Basin
39	Eucla	Australia South Coast	Little Explored	Onshore and Offshore	Divergent Basin
40	Polda	Australia South Coast	Little Explored	Onshore and Offshore	Divergent Basin
41	Bass	Australia South Coast	Partially Explored	Onshore and Offshore	Divergent Basin
42	Karoo	Central and South Africa Interior	Little Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
43	Outeniqua	Circum-South Atlantic (Africa)	Partially Explored	Onshore and Offshore	Divergent Basin
44	Rovuma	East Africa	Little Explored	Onshore and Offshore	Divergent Basin
45	Diego Ambilobe	East Africa	Little Explored	Onshore and Offshore	Divergent Basin
46	Mozambique	East Africa	Partially Explored	Onshore and Offshore	Divergent Basin
47	Tanzanian Coastal	East Africa	Partially Explored	Onshore and Offshore	Divergent Basin

Fid	Basin Name	Basin Location	Exploration Status	Offshore Location	Basin Type
48	Morondava	East Africa	Partially Explored	Onshore and Offshore	Divergent Basin
49	Lamu Embayment	East Africa	Partially Explored	Onshore and Offshore	Divergent Basin
50	Majunga	East Africa	Little Explored	Onshore and Offshore	Divergent Basin
51	Cagayan	East Philippines	Unknown	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
52	Visayan-Iloilo-Masbate	East Philippines	Unknown	Onshore and Offshore	Convergent (Ocean–Continent) Basin
53	Agusan-Davao	East Philippines	Unknown	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
54	Bicol Shelf	East Philippines	Unknown	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
55	West Luzon	East Philippines	Unknown	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
56	Cotabato	East Philippines	Unknown	Onshore and Offshore	Convergent (Ocean–Continent) Basin
57	Luzon-Ilocos Trough	East Philippines	Unknown	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
58	Buton	Eastern Indonesia	Little Explored	Onshore and Offshore	Divergent Basin
59	North New Guinea	Eastern Indonesia	Little Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
60	South Makassar	Eastern Indonesia	Little Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
61	South Sumba	Eastern Indonesia	Unknown	Onshore and Offshore	Convergent (Ocean–Continent) Basin
62	Waipoga	Eastern Indonesia	Partially Explored	Onshore and Offshore	Wrench Basin
63	Seram	Eastern Indonesia	Partially Explored	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
64	Sengkang Bone	Eastern Indonesia	Partially Explored	Onshore and Offshore	Divergent Basin
65	Buru	Eastern Indonesia	Unexplored	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
66	Banggai Sula	Eastern Indonesia	Little Explored	Onshore and Offshore	Convergent (Continent–Continent) Basin
67	Lariang	Eastern Indonesia	Little Explored	Onshore and Offshore	Convergent (Continent–Continent) Basin
68	Papuan	Eastern Indonesia	Partially Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
69	Salawati	Eastern Indonesia	Partially Explored	Onshore and Offshore	Wrench Basin
70	Viqueque	Eastern Indonesia	Partially Explored	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
71	Halmahera	Eastern Indonesia	Unexplored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
72	Kai-Aru Trough	Eastern Indonesia	Little Explored	Onshore and Offshore	Divergent Basin
73	Tanimbar	Eastern Indonesia	Unexplored	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
74	Bintuni	Eastern Indonesia	Partially Explored	Onshore and Offshore	Wrench Basin

Fid	Basin Name	Basin Location	Exploration Status	Offshore Location	Basin Type
75	Weber	Eastern Indonesia	Unknown	Onshore and Offshore	Convergent (Ocean–Continent) Basin
76	Irian Arafura	Eastern Indonesia	Little Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
77	North China	Eastern Paratethys	Well Explored	Onshore and Offshore	Divergent Basin
78	Jiao Liao	Eastern Paratethys	Unexplored	Onshore and Offshore	Divergent Basin
79	Krishna-Godavari	India and the Seychelles	Partially Explored	Onshore and Offshore	Divergent Basin
80	Mannar	India and the Seychelles	Little Explored	Onshore and Offshore	Divergent Basin
81	Kachchh	India and the Seychelles	Little Explored	Onshore and Offshore	Divergent Basin
82	Konkan-Kerala	India and the Seychelles	Little Explored	Onshore and Offshore	Divergent Basin
83	Tripura-Cachar Foldbelt-Bengal	India and the Seychelles	Partially Explored	Onshore and Offshore	Divergent Basin
84	Cambay	India and the Seychelles	Well Explored	Onshore and Offshore	Divergent Basin
85	Mumbai-Saurashtra	India and the Seychelles	Well Explored	Onshore and Offshore	Divergent Basin
86	Indus	India and the Seychelles	Well Explored	Onshore and Offshore	Convergent (Continent–Continent) Basin
87	Offshore Indus	India and the Seychelles	Little Explored	Onshore and Offshore	Divergent Basin
88	Bengal Delta Sub-basin-Bengal	India and the Seychelles	Partially Explored	Onshore and Offshore	Divergent Basin
89	Cauvery	India and the Seychelles	Well Explored	Onshore and Offshore	Divergent Basin
90	Mahanadi	India and the Seychelles	Little Explored	Onshore and Offshore	Divergent Basin
91	Seychelles Bank	India and the Seychelles	Little Explored	Onshore and Offshore	Divergent Basin
92	Moattama-Tanintharyi	Indo-China	Partially Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
93	Greater Thai	Indo-China	Well Explored	Onshore and Offshore	Divergent Basin
94	Arakan	Indo-China	Little Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
95	Bac Bo-Yinggehai	Indo-China	Partially Explored	Onshore and Offshore	Divergent Basin
96	Central Myanmar Tertiary	Indo-China	Partially Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
97	Cuu Long	Indo-China	Partially Explored	Onshore and Offshore	Divergent Basin
98	Panjang	Indo-China	Unexplored	Onshore and Offshore	Divergent Basin
99	Greater Chao Phraya	Indo-China	Well Explored	Onshore and Offshore	Divergent Basin
100	Pattani	Indo-China	Well Explored	Onshore and Offshore	Divergent Basin
101	Sabah-Baram Delta	Indo-China	Well Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin

Fid	Basin Name	Basin Location	Exploration Status	Offshore Location	Basin Type
102	Sarawak-Luconia-East Natuna	Indo-China	Partially Explored	Onshore and Offshore	Divergent Basin
103	Ile St. Marie	Madagascar South and East	Little Explored	Onshore and Offshore	Divergent Basin
104	Cap St. Marie	Madagascar South and East	Unexplored	Onshore and Offshore	Divergent Basin
105	Makran Foldbelt	Middle East	Little Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
106	Masirah	Middle East	Little Explored	Onshore and Offshore	Divergent Basin
107	Oman Mountains Foldbelt	Middle East	Partially Explored	Onshore and Offshore	Convergent (Continent–Continent) Basin
108	Rub al Khali	Middle East	Well Explored	Onshore and Offshore	Convergent (Continent–Continent) Basin
109	Widyan-North Arabian Gulf	Middle East	Well Explored	Onshore and Offshore	Convergent (Continent–Continent) Basin
110	Zagros Foldbelt	Middle East	Well Explored	Onshore and Offshore	Convergent (Continent–Continent) Basin
111	Perth	Northwest Australia	Well Explored	Onshore and Offshore	Divergent Basin
112	South Carnarvon	Northwest Australia	Partially Explored	Onshore and Offshore	Divergent Basin
113	Tosa	Pacific Far East	Unknown	Onshore and Offshore	Convergent (Ocean–Continent) Basin
114	Toki	Pacific Far East	Unknown	Onshore and Offshore	Convergent (Ocean–Continent) Basin
115	Okinawa Trough	Pacific Far East	Unknown	Onshore and Offshore	Convergent (Ocean–Continent) Basin
116	Ryukyu Forearc	Pacific Far East	Unknown	Onshore and Offshore	Convergent (Ocean–Continent) Basin
117	Suruga	Pacific Far East	Unknown	Onshore and Offshore	Convergent (Ocean–Continent) Basin
118	Miyazaki	Pacific Far East	Unknown	Onshore and Offshore	Convergent (Ocean–Continent) Basin
119	Central Solomon Trough	Pacific Southwest	Unknown	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
120	Vanikolo	Pacific Southwest	Unknown	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
121	Big Bay-Cumberland	Pacific Southwest	Unknown	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
122	Woodlark Rise	Pacific Southwest	Unknown	Onshore and Offshore	Convergent (Ocean–Continent) Basin
123	Bougainville	Pacific Southwest	Unknown	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
124	New Ireland	Pacific Southwest	Unknown	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
125	Central Vanuatu	Pacific Southwest	Unknown	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
126	Fiji	Pacific Southwest	Unknown	Onshore and Offshore	Convergent (Ocean–Ocean) Basin
127	Somali-Ogaden-Mandera Lugh	Red Sea, Gulf of Aden, and the Horn of Africa	Partially Explored	Onshore and Offshore	Divergent Basin

Fid	Basin Name	Basin Location	Exploration Status	Offshore Location	Basin Type
128	Southern Gulf of Aden	Red Sea, Gulf of Aden, and the Horn of Africa	Little Explored	Onshore and Offshore	Divergent Basin
129	Jiza'-Qamar	Red Sea, Gulf of Aden, and the Horn of Africa	Partially Explored	Onshore and Offshore	Divergent Basin
130	Mogadishu-Somali Coastal	Red Sea, Gulf of Aden, and the Horn of Africa	Little Explored	Onshore and Offshore	Divergent Basin
131	Sayhut	Red Sea, Gulf of Aden, and the Horn of Africa	Little Explored	Onshore and Offshore	Divergent Basin
132	Aden-Abiyan	Red Sea, Gulf of Aden, and the Horn of Africa	Little Explored	Onshore and Offshore	Divergent Basin
133	Sagaleh	Red Sea, Gulf of Aden, and the Horn of Africa	Partially Explored	Onshore and Offshore	Divergent Basin
134	Balhaf	Red Sea, Gulf of Aden, and the Horn of Africa	Little Explored	Onshore and Offshore	Divergent Basin
135	San Shui	South China	Unknown	Onshore and Offshore	Divergent Basin
136	Hangjiahu	South China	Unknown	Onshore and Offshore	Divergent Basin
137	Qinzhou	South China	Unknown	Onshore and Offshore	Divergent Basin
138	West Hainan	Southeast China	Partially Explored	Onshore and Offshore	Divergent Basin
139	Beibu Gulf	Southeast China	Partially Explored	Onshore and Offshore	Divergent Basin
140	Pearl River Mouth	Southeast China	Partially Explored	Onshore and Offshore	Divergent Basin
141	Subei-Yellow Sea	Southeast China	Partially Explored	Onshore and Offshore	Divergent Basin
142	Taiwan	Southeast China	Partially Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
143	West Korea	Southeast China	Partially Explored	Onshore and Offshore	Divergent Basin
144	Sulu Sea	West Philippines	Partially Explored	Onshore and Offshore	Divergent Basin
145	South Palawan	West Philippines	Partially Explored	Onshore and Offshore	Divergent Basin
146	Mindoro	West Philippines	Partially Explored	Onshore and Offshore	Convergent (Continent–Continent) Basin
147	North Palawan	West Philippines	Partially Explored	Onshore and Offshore	Divergent Basin
148	Central Sumatra	Western Indonesia	Well Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
149	North Sumatra-Mergui	Western Indonesia	Partially Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
150	Northwest Java	Western Indonesia	Well Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
151	Sunda	Western Indonesia	Well Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin

Fid	Basin Name	Basin Location	Exploration Status	Offshore Location	Basin Type
152	Kutei	Western Indonesia	Well Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
153	East Java	Western Indonesia	Partially Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
154	Tarakan	Western Indonesia	Partially Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
155	Sibolga	Western Indonesia	Little Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
156	Andaman-Nicobar	Western Indonesia	Little Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
157	Barito	Western Indonesia	Partially Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
158	Bengkulu	Western Indonesia	Little Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
159	South Java	Western Indonesia	Little Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
160	South Sumatra	Western Indonesia	Well Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
161	Java Sea	Western Indonesia	Partially Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
162	Pasir-Asem Asem	Western Indonesia	Little Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin
163	Sandakan	Western Indonesia	Partially Explored	Onshore and Offshore	Convergent (Ocean–Continent) Basin

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