The Last Hydrocarbon Frontier Region in East Africa: Geographical Distribution of the Underexplored Potential Hydrocarbon Basins of Somalia.

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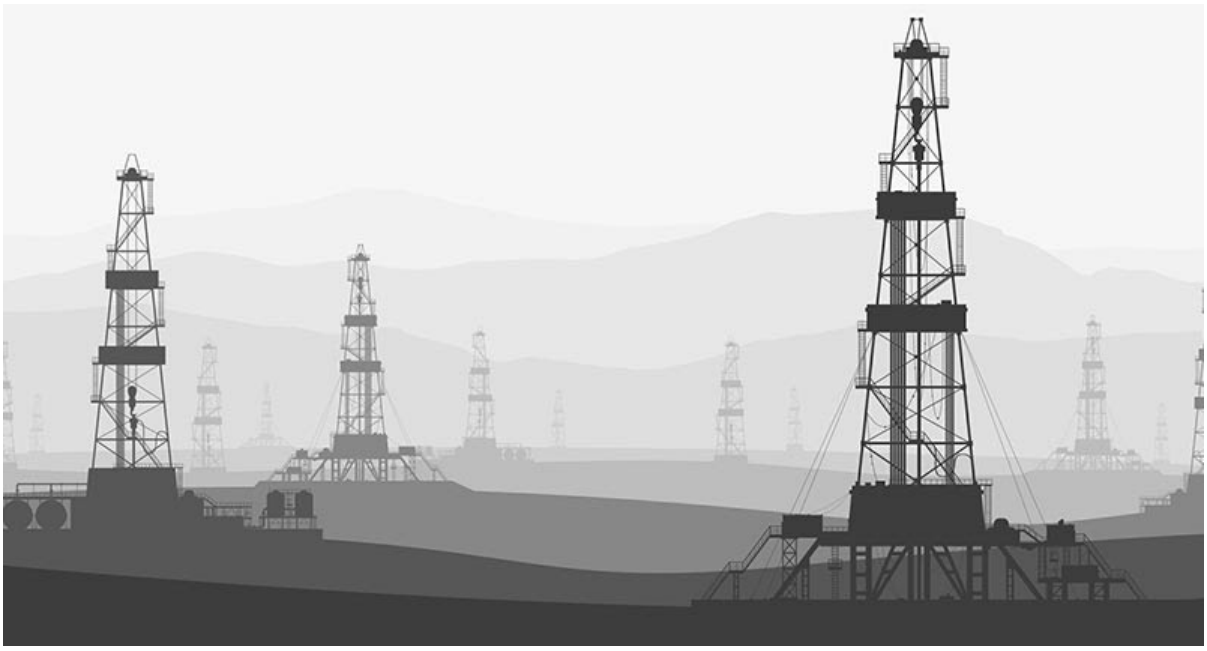


Introduction

Somalia is situated in the easternmost part of Africa and is known as Horn of Africa. Somalia geopolitically occupies a very strategic place along major sea transportation routes in the Middle East and Asia. Somalia is bounded by the Gulf of Aden to the north, Indian Ocean to east, Kenya and Ethiopia to the west, and Djibouti to the northwest. The country has a land mass area of approximately **640,000 km2**, an extensive maritime area of approximately **835,332 km2** in size and a coastline of over **3,000 km**, which makes Somalia the country with longest coastline in Africa.

Geographically, the country has eighteen regions ***(Fig. 2)***, and generally, consists of four major landscapes ***(Fig. 1)***; Costal zones, highlands (mountainous area, up to 2,500 meters above the sea-level), plateaus and plains. In the north along the Gulf of Aden, there is coastal low land that abruptly ends to the south by the mountainous ranges known as Golis (Qar Goolis) in the northwest, and Als (Cal) in the northeast part of the country.

Fig: 1- Somalia Physiography with Maritime Boundaries

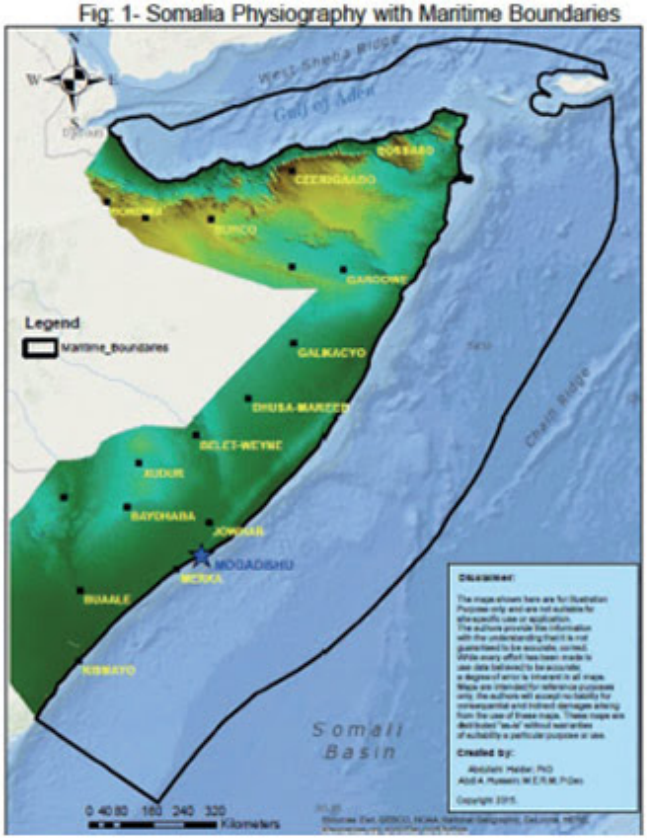
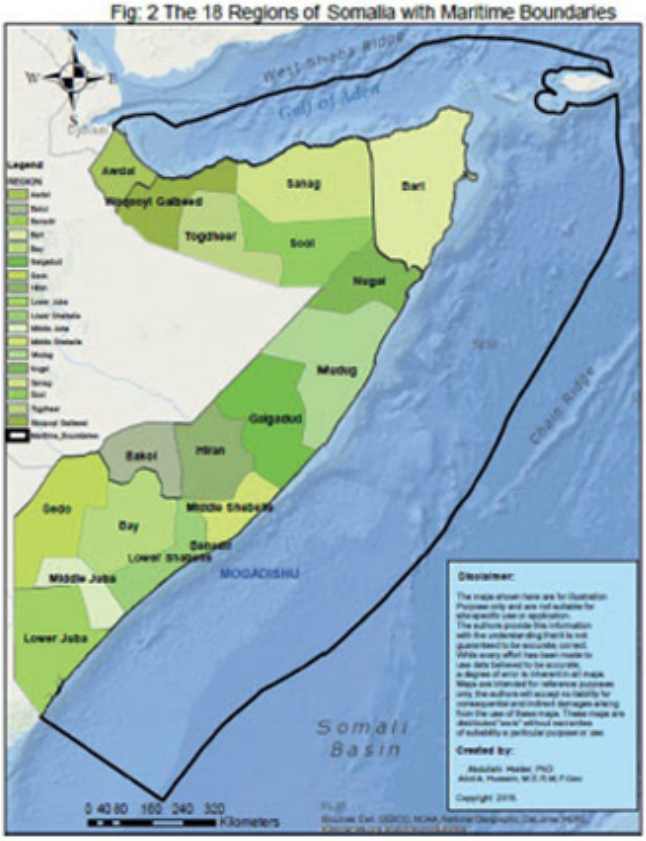


Fig: 2 The 18 Regions of Somalia with Maritime Boundaries



The northern mountains give way to plateaus (Oogo) that are interrupted by deep valleys. The elevations of the plateau gradually drop into plains, which then steadily descend to the south towards the Indian Ocean. The country has two permanent rivers; which are Juba and Shabelle that flow from Ethiopian highlands and drain into Indian Ocean.

Sedimentary basins in Somalia and their hydrocarbon resource potential

Geologically, the presences of sedimentary rocks (layers of rocks) are the primary elements necessary though not sufficient for assessing hydrocarbon potential of an area. Throughout the geologic times, over millions of years, the Somali territory was subjected to a number of geological cycles during which tectonic activities of the earth created various types of uplifts, depressions and rifting that resulted in the formation of sedimentary basins, both on land (on-shore) and in the sea (off-shore), which cover almost over 90% of the country. The sedimentary basins of Somalia have very thick, over 8000 m of sedimentary sequence of various rock types that were deposited over different geological times.

According to Ali M. Naley and J.C. Harms 1993 (Naleye, 1993), there are six onshore sedimentary basins (Fig. 3) in Somalia; and the following is a summary of each basin:

1. **Guban basin:** is the sedimentary basin; which covers mainly northwest along the Gulf of Aden with an onshore area of approximately **31,870 km2**. The Guban basin extends into the Gulf of Aden to an offshore extent, possibly bigger than its onshore area. The total number of wells drilled in this basin is **11; 9** are onshore, and **2** are offshore.

2. Darror-Nugal basin: is the sedimentary basin; which mainly covers the northeast part of Somalia along the Indian Ocean. The basin (Darror-Nugal basin) covers approximately an onshore area of **167,838 km2**. The basin extends into the Indian Ocean to an extent that is possibly bigger than its onshore area; which has not yet been delineated. The total number of wells drilled in this basin is **19; 15** are onshore and **4** are offshore.

3. Central/Mudug basin: is the sedimentary basin that occupies much of the central part of the country along the Indian Ocean. The Mudug basin has an area of approximately **169,651 km2;** and this basin also has an offshore area that is as big as its onshore area or bigger. The total number of wells drilled is **16; 14** are onshore and **2** are offshore wells.

4. Qorioley (Coriole) basin: is the onshore basin that occupies much of the capital city, Mogadishu, and the surrounding regions along the Indian Ocean. The Qoryooley basin occupies an area of approximately **27,077 km2**; and the basin has an offshore area, which extends into the Indian Ocean that is also possibly bigger than its onshore area. The total number of wells drilled is **11;** all are onshore.

5. Luuq-Mandheera basin: is the basin that is situated at the southwestern part of the country along the Ethiopian and Kenyan borders. Luuq-Mandheera basin has an area of approximately **89,003 km2** with only 3 wells drilled. Besides this, the Basin has no offshore extension, as it does not border the sea.

6. Jubba-Lamu basin: is an onshore basin; which lays to the most southern part of the country, along the Indian Ocean and bordering Kenya. The Juba-Lamu basin covers an onshore area of approximately **54,826 km2**; the basin has an offshore component that is possibly bigger than its onshore area. The numbers of wells drilled are **6** onshore and zero offshore.

In order for a sedimentary basin to have a hydrocarbon accumulation, there must first be a source rock which generates hydrocarbons; secondly a reservoir rock, a porous rock, must exist in the basin for the generated hydrocarbon to migrate into; thirdly after the hydrocarbon migrates into the reservoir, there must be an impermeable barrier (cap rock/seal) which seals the hydrocarbon from escaping the reservoir. Additionally in order for the hydrocarbon to accumulate under the sealed reservoir there must be structural and/or stratigraphic traps that block the lateral migration of the hydrocarbon. Once all the above-mentioned rock types are in place, the final and critical element is the timing.

Timing determines the succession of the geologic events that produce the other four geological attributes (source, reservoir and cap rocks; and the structural/stratigraphic traps) relative to the migration of the hydrocarbon. If the cap rock (seal) and traps are formed before the generated hydrocarbon migration is started, then there will be hydrocarbon accumulation in the reservoir. However, there will be very little or no hydrocarbon accumulations entirely if the seal/cap rock, and traps are produced after the hydrocarbon migration.

Hydrocarbon exploration started in Somalia during the colonial era when the British colony found large oil seepage in Dhagax Shabeel situated in northwestern Somalia. Hydrocarbon exploration relatively increased during the 1950s and 1960s when the majority of exploration/stratigraphic wells were drilled in different parts of the country.

Although the sporadic oil and gas exploration activities in the country did not find commercial quantities of oil and gas, the exploration data established that the country's sedimentary basins have working oil and gas producing geological system. In addition to the above mentioned oil seepage, a number of exploration wells in different parts of the country have shown the presence of oil and gas at different quantities. However, despite the presence of physical evidence; which shows the existence of a working petroleum system, the country remained underexplored. The following section will explain the reason why Somalia has remained underexplored.

Somalia, from oil and gas industry point of view, is called the last of East Africa's frontier basins. In oil and gas exploration and production (E&P), the term(s) "Frontier" or "Frontier Basin/Frontier Region" are used for both onshore and offshore basins, which are considered to have huge volumes of undiscovered oil and gas resources.

According to David E. Brown of the United States Strategic Studies Institute's 2013 monograph, the estimated onshore and offshore oil reserves is 110 billion barrels and in addition the country is known to have significant deposits of natural gas (David E, Brown, 2013).

The frontier regions are either unexplored or sporadic exploration activities were undertaken due to political instability, unfriendly business environment, geographical remoteness (difficult terrain, deep sea and etc.) and or technological barriers. The oil and gas exploration of a frontier basin will remain in what is known as the "frontier exploration phase" where the focus of the oil company will be to conduct low cost exploration methods such as Arial magnetic and gravimetric surveys with few regional (widely spaced) seismic lines to map large areas where they try to identify large structures with potential for huge oil accumulation. A frontier region could remain under a frontier exploration phase status until such time that the above-mentioned barriers i.e., non-conducive environment, political and technological barriers will no longer exist.

From the beginning in the 1950s to present day, Somalia's petroleum exploration was in a Frontier Exploration Phase. As a result of being in a frontier exploration phase, Somalia is significantly under explored relative to the country's promising potential hydrocarbon basins. The seismic survey grid was coarse (wide spaced) and sporadic in many places; and there are only 66 exploration wells, for which only 8 wells are offshore with the maritime area of approximately 835, 332 km2.

Table 1 below shows the low density of the exploration wells per basin in the country (number of wells per area):

# Basin name	# Onshore wells	# Offshore wells	Basin area (km2)	# Onshore wells/km2 (Density of wells)
Guban Basin	9	2	31,870	0.0003
Darror-Nugal Basin	15	4	167,838	0.00009
Central/Mudug Basin	14	2	169,651	0.00008
Qorioley Basin	11	0	21,077	0.0005
Jubba-Lamu Basin	6	0	54,826	0.0001
Luuq-Mandheera Basin	3	0	89,003	0.00003

Based on the available information, all of the above mentioned sedimentary basins in Somalia have favorable geologic attributes such as source rock, reservoir rock, and cap rock, structural and stratigraphic traps for hydrocarbon accumulation. The reasons as to why Somalia was in a frontier exploration phase for such a long time were mainly due to the political instability and lack of attractive business environment that encouraged international oil companies to invest in Somalia; and to a lesser extent lack of technical capability for deep sea drilling.

However, due to cost efficient technological advances in the oil and gas exploration industry, many parts of the world with potential hydrocarbon basins that was in the state of frontier exploration phase for technical reasons were explored and became petroleum-producing regions.

Some examples are the Gulf of Mexico, the North Sea and Africa's west coast. Therefore, since there are technical innovations enabling the exploration and exploitation of these frontier basins, the major international oil companies are showing a renewed interest in Somalia's promising potential hydrocarbon basins (the last frontier region in East Africa).

Fig: 3 Somali Sedimentary Basins with Maritime Boundaries

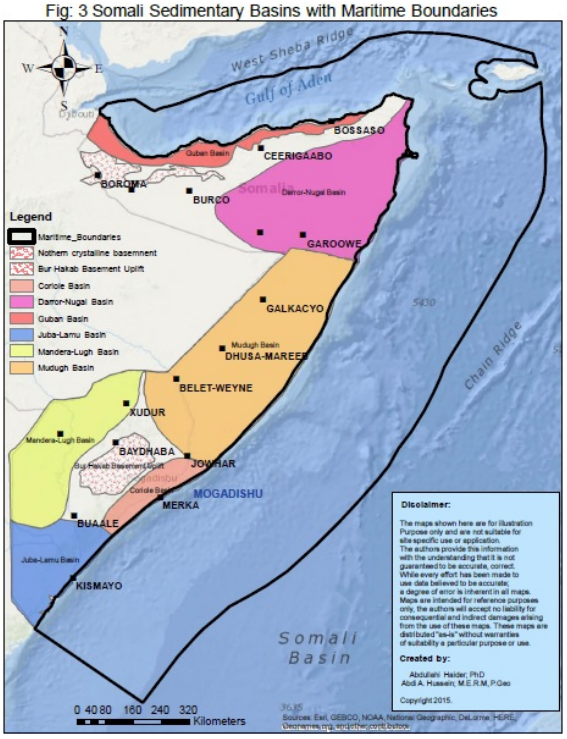
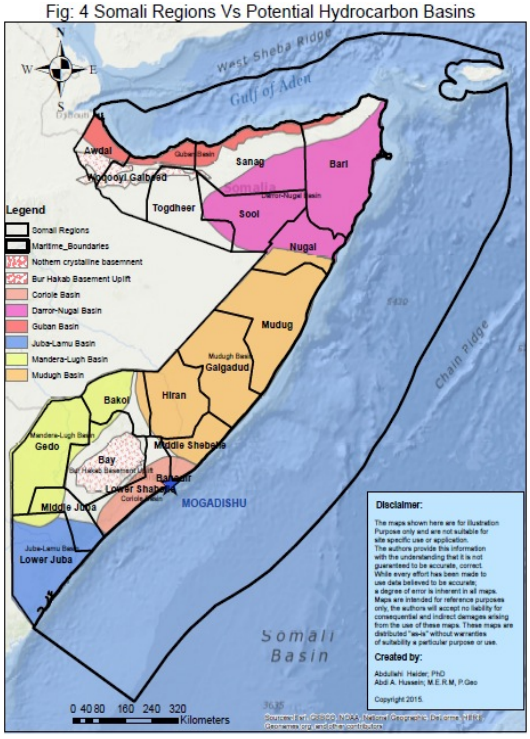


Fig: 4 Somali Regions Vs Potential Hydrocarbon Basins



Conclusion

Somalia possesses all the requirements for a petroleum province. There are hydrocarbons that have been generated from Jurassic, cretaceous and tertiary rocks with sedimentary columns reaching a thickness of 8830m. Many reservoirs (porous rocks) are also known to exist within these sedimentary columns of both in carbonate and clastic rock types. In addition various types of traps have also been identified. Overall, the very low density of wells per sedimentary basin and the number of the total wells drilled relative to the whole surface of the country demonstrates that Somalia is underexplored.

Many oil experts believe that Somalia's hydrocarbon potential is very promising with estimated onshore and offshore oil reserves of 110 billion barrels (David E, Brown, 2013). The sedimentary basins that are prone to generate hydrocarbons underlie all the 18 regions of Somalia. There is an equal opportunity for every region to discover hydrocarbon in Somalia and some regions extend over into several potential sedimentary basins see figures 3 and 4.

Despite technological advances; which would allow Somalia to progress past the frontier exploration phase, the country needs to obtain political stability and security in order to attract international investment necessary for further exploration and development. Once the country embarks on the mentioned course, major international oil companies who have shown renewed interest will return immediately and resume exploration.

The only thing holding Somalia back from exploiting its significant oil and gas resources are the political barriers it faces. Now is the time for Somalia to strip away these barriers and make the country an appealing and effective place for foreign investment from major International Oil and Gas Companies.

The Somali people, academia, technocrats and the politicians need to work together in order to create an attractive political and business atmosphere so as not to underserve a nation with incredible natural resource potential.

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