Submitted Abstract

The Petroleum System of Offshore Somalia: A Potential Mega-Province

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Introduction

Offshore Eastern Africa emerged as a major new petroleum province through the second decade of the 21st century (2018; Davison and Steele, 2018; Sayers, 2017; Davidson et al, 2018). A combination of Jurassic source rocks (unpenetrated, but inferred, e.g. Sayers, 2017) and Cretaceous and Tertiary clastic reservoirs came together to deliver world-class gas discoveries in the offshore basins of Kenya, Tanzania and Mozambique.

While the same petroleum system clearly extended northwards into offshore Somalia, political instability in the Horn of Africa suppressed interest in exploration, although an extensive 2D seismic dataset was collected in the period 2014 -16 (Davidson et al 2018).

The authors have used those data to generate a play-level analysis of the petroleum system on the Somali passive margin. A likely source interval in the Jurassic rift/sag sequence has been interpreted on good quality attribute-processed 2D seismic data and burial history/maturity modelling has shown that, unlike the equivalent interval to the south, across a large portion of the basin largely still within the oil window. The results of that study are summarized here.

Method

Only one well has been drilled in the offshore to calibrate geothermal gradient (Pomboo-1, Woodside 2007), although additional information is available in a number of onshore wells (Figure 1).

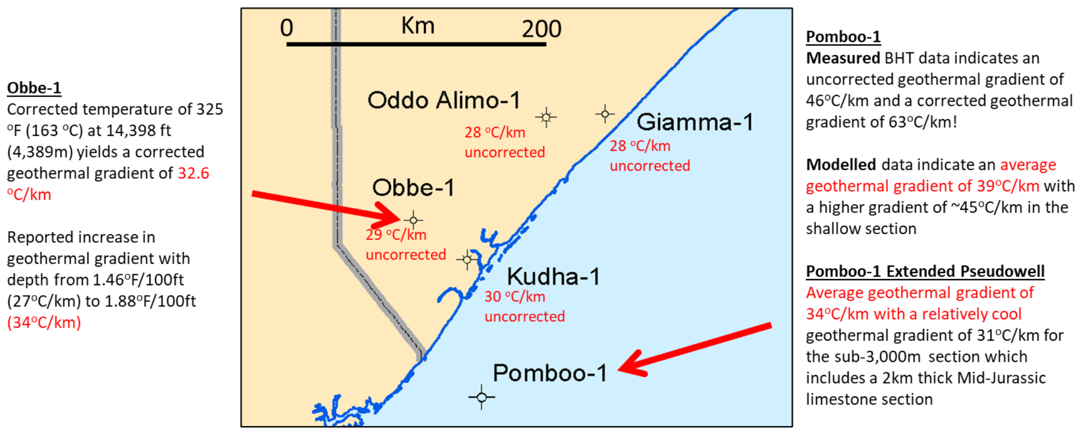

***Figure 1** Thermal gradient data from wells in southern Somalia onshore and offshore*

The depth-converted seismic data were used to interpret 7 significant geological surfaces from top "basement" through the Jurassic rift/post-rift section and the Cretaceous/Tertiary drift interval across three sub-basins: the Jubba Deep, Mogadishu, and Mid-Somalia High (Figure 2). These surfaces were used to construct isopach maps for both the interpreted Middle to Upper Jurassic restricted marine source rock intervals and the overburden units. These maps and volumes provided the basic input data for the Temis model. The gross isopachs for the two likely source intervals (165-161Ma and 161-145Ma) are shown in Figure 2.

The source rock has not been penetrated in the basin, so SR properties for input to the model were modelled on the basis of values from regional analogues:

- The Hanifa of the Arabian intrashelf basins (ca. 156-153Ma) e.g. Pepper and Roller (2021)
- Middle (ca. 170 – 165Ma) and Upper (ca. 154-152Ma) Jurassic source rocks sampled in wells in the Majunga Basin of Madagascar e.g. Davison and Steele (2018)

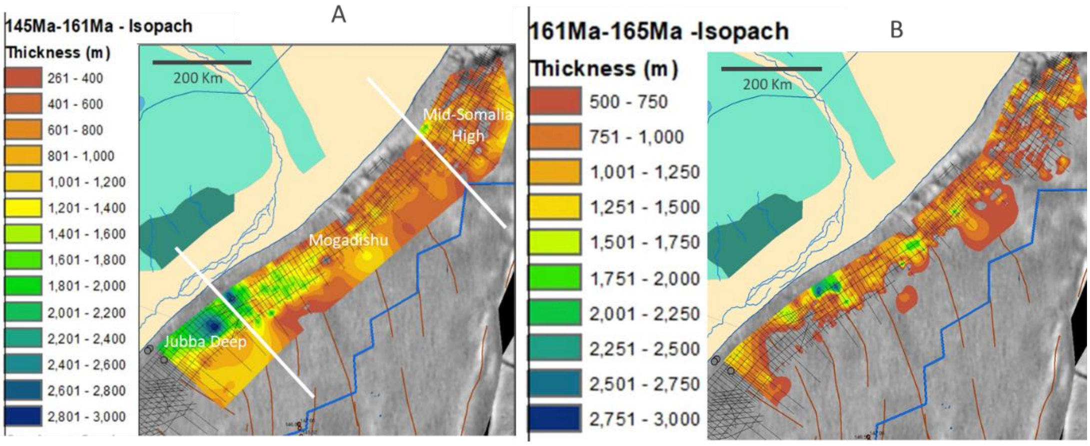

Figure 2 *Gross Isopach maps for the two Jurassic source rock-prone intervals Offshore Somalia: A Callovian to Tithonian, B: Bathonian*

Projecting the calculated geothermal gradient across the basin, present-day source rock maturity was estimated at three horizons within the interval: 165Ma (Bathonian, base of probable source interval); 161Ma (Callovian) and 145Ma (Tithonian, top of probable source interval)

- At 165Ma, the majority of the Mogadishu and Jubba Deep basins are in the dry gas window, while the Mid-Somalia High is partly in the oil window, and partly in the wet gas window (Figure 3A).

- At 161Ma, most of the Jubba Deep and Mogadishu basins are in the gas/wet gas window, and the Mid Somalia High is largely in the oil window (Figure 3B)

- At 145Ma, significant portions of the Mogadishu Basin are in the oil window, the Jubba Deep is more gas-prone, and the Mid-Somalia high is largely immature (Figure 3C)

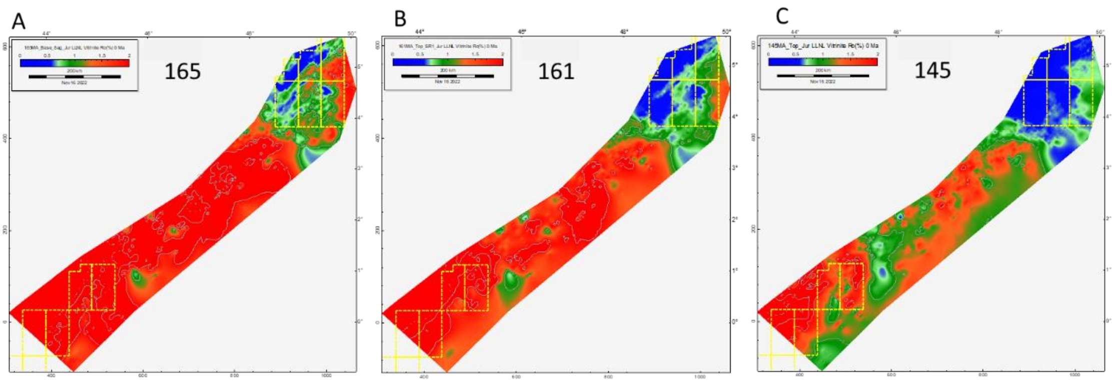

Figure 3 *Calculated present-day maturity of the Jurassic source-prone interval at the base of the interval (A), mid-interval (B) and top-interval (C).*

Because the source rock has not been penetrated, and the geothermal gradient is poorly-constrained, a monte-carlo sensitivity analysis was undertaken for a notional trap to assess the factors that would cause the greatest problems to success in the basin should they fall outside the ranges estimated.

The sensitivities tested were Geothermal Gradient; Source Hydrogen Index and Total Organic Carbon content, Source Kinetics, Source Thickness, Source Depth, Migration Loss for Oil and Gas, Trap Age, and Fetch Area. Tornado charts were generated for oil charge (Figure 4) and gas charge (Figure 5).

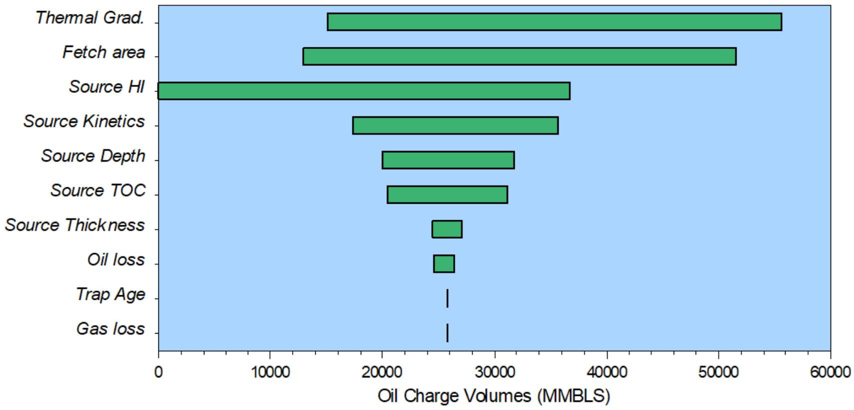

Figure 4 *Oil Charge Tornado diagram. The only parameter reducing charge to less than 1 billion barrels is the HI. The thermal gradient is highly sensitive for shallower source intervals.*

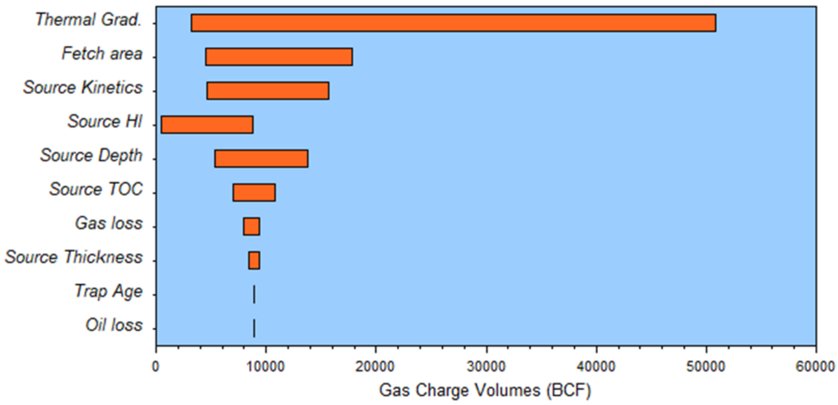

Figure 5 *Gas Charge Tornado diagram. The only parameter reducing charge to less than a trillion cubic feet is the HI. The thermal gradient is highly sensitive for shallower source intervals.*

Results

Mapping of potential reservoir intervals in the Cretaceous and Palaeogene of the oil and gas-prone Mogadishu Basin has demonstrated that inversion-driven highs have the potential to focus significant charge into associated structural or stratigraphic closures.

In the gas-prone Jubba Deep basin, structural closures associated with gravity-slide fold-belt structures have a higher risk of being in a migration shadow. It is noteworthy in this respect that most of the surface seepage in the basin is found along the coastline of the Jubba Deep.

The Mid-Somalia High has been a prominent feature for most of the history of the basin, and as such has been a focus for migration from the source basins associated with it.

Conclusions

An analysis of the petroleum system of the offshore basins of Somalia has been undertaken. Regional analogues and seismic mapping indicate the presence of a world-class Jurassic source interval with the potential to have generated billions of barrels of oil (Figure 6, Table 1) and trillions of cubic feet of gas (Figure 7, Table 1). There are significant sub-regional highs driven by the tectonic evolution of the margin that could behave as charge foci. There are potential carbonate and clastic reservoir intervals in the Jurassic, Cretaceous and Palaeocene.

Offshore Somalia has the potential to be a significant hydrocarbon province.

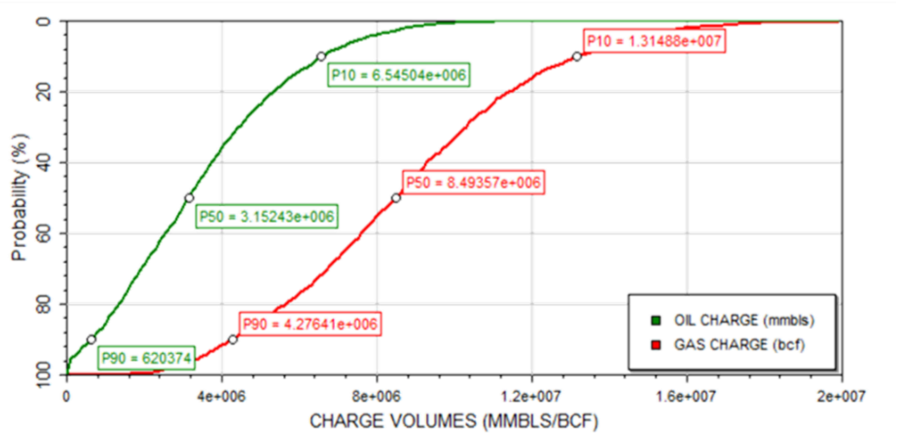

Figure 6 *Oil and Gas Volume Expelled Probability for 165-161 Source Rock*

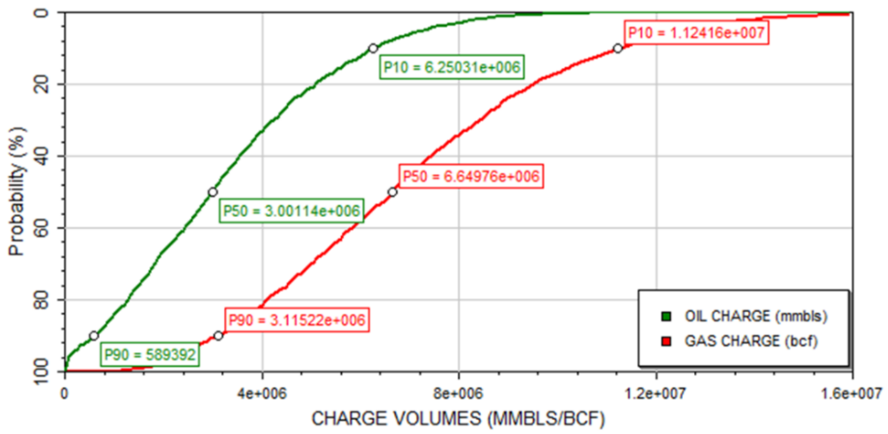

Figure 7 *Oil and gas Expelled volumes 161-145 Source Rock*

Zone	P50 Oil (Billion Barrels)	P50 (Trillion Cubic Feet)
165-161 MA Source Rock	620	4,300
161-145 MA Source Rock	590	3,100
Total	1,210	7,400

Table 1 *Assessed hydrocarbon volumes expelled from Jurassic source intervals*

References

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