Submitted abstract

A Frontier Fairway in East Africa: The Carbonate Play of the Mid-Somalia High

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Introduction

In the second decade of the twenty-first century, a major new petroleum province was opened in Eastern Africa, where Jurassic source rocks and Cretaceous and Tertiary clastic reservoirs came together to deliver world-class gas discoveries in the offshore basins of Kenya, Tanzania and Mozambique.

It was clear that the same petroleum system extended northwards into offshore Somalia, but long-running civil conflict and an Islamist insurgency resulted in little interest in exploration. With an eye to future stability, however, an extensive offshore 2D seismic survey (16,550 line kilometres on a 10 x 20km basic grid) was acquired by Spectrum ASA (now TGS) in 2014 to 2016 (Figure 1).

The authors have used those data to generate a play-level analysis of the petroleum system on the Somali passive margin. Clastic and Carbonate plays have been identified, and critically it has been recognized that the Jurassic source rocks in the basin, unlike the equivalent interval to the south, are largely still within the oil window. This abstract provides a brief summary of the portion of that study describing the carbonate play.

Method

Three wells tied into the seismic grid (Figure 1: DSDP Site 241, 1974; Meregh-1, Esso, 1982, and Pomboo-1, Woodside 2007) were used to calibrate the interpretation of 7 significant geological surfaces (Table 1) across three sub-basins: the Jubba Deep, Mogadishu Deep, and Mid-Somalia High (Figure 1). Additional data included publicly available gravity and magnetic surveys and prior studies of the basin, most notably that of Davidson et al. (2018).

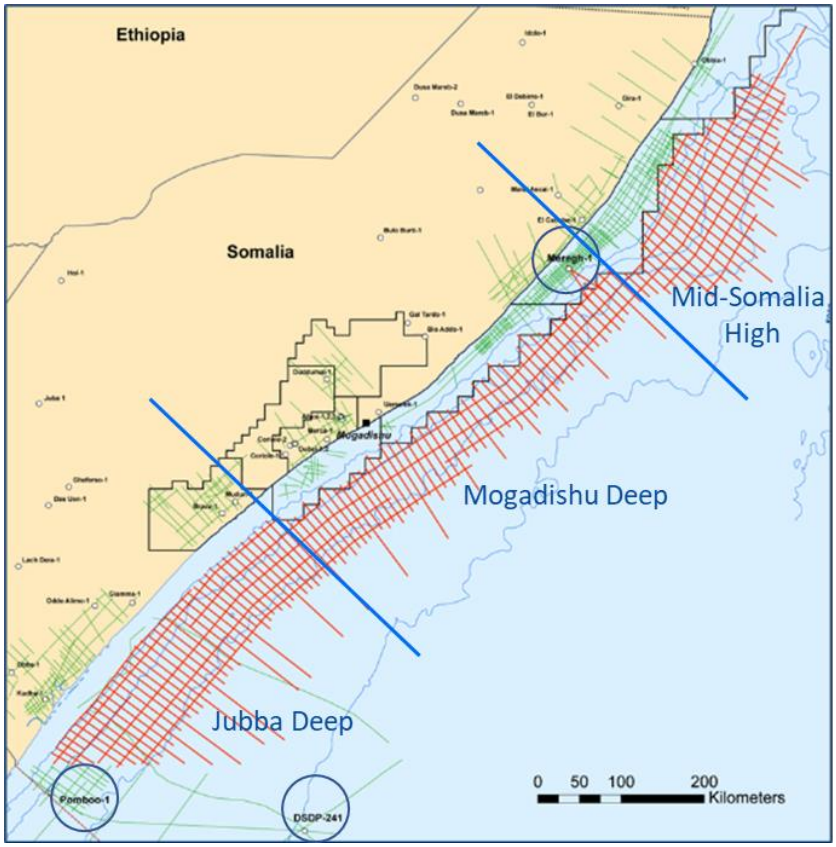

Figure 1 *Interpreted seismic grid (red) and wells used for calibration and major sub-basins in the Somali passive margin basin (modified from Davidson et al. 2018).*

Era	Stage	Age
Palaeogene	Thanetian	55ma
Cretaceous	Campanian	75Ma
	Aptian	120Ma
Jurassic	Tithonian	145Ma
	Callovian	161Ma
	Bathonian	165Ma
	Aalenian	175Ma

Table 1 *Horizons interpreted across the basin*

The Carbonate Play Fairway

Through the Middle to Late Jurassic (175 – 145 Ma), the northern and southern margins of the Tethyan Seaway and its western extensions into the proto-Atlantic and -Gulf of Mexico basins were a locus of prolific carbonate development in wide, shallow epeiric shelf settings. The effectiveness of the petroleum systems developed in these basins is significantly enhanced by the association of carbonate reservoir deposition with the co-eval development of oil-prone source rocks in intra-shelf deeps and evaporite seals.

Present-day Somalia lay on the south-eastern margin of the seaway, immediately south of the contemporary equator, in a southerly extension of an extensive contiguous but locally differentiated basin termed by some authors “Afro-Arabia” (Gerdes et at 2010), Figure 2.

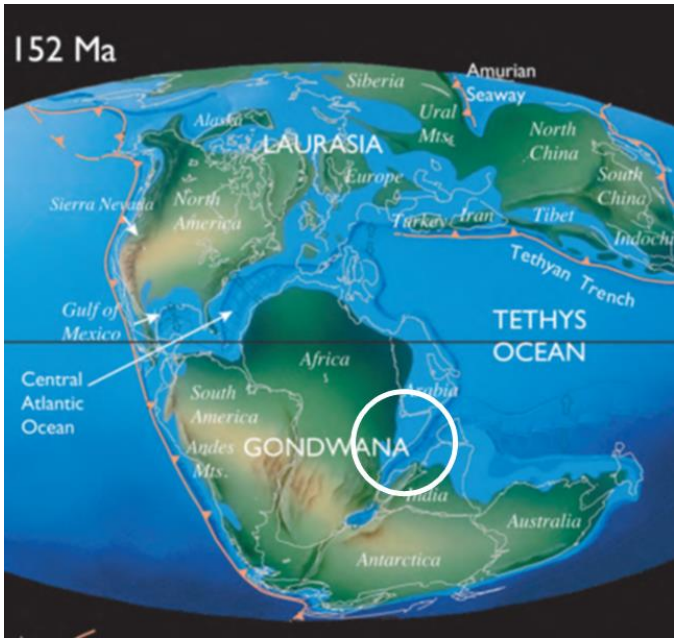

Figure 2 *Palaeoreconstruction of Tethyan palaeogeography after rifting of Madagascar from Somalia, prior to the sseparation of the Indian and Antarctic plates. From Scotese, 2001*

The Mid-Somalia High (MSH) is a fragment of continental crust that remained attached to continental Africa as continental rifting initiated in the early Middle Jurassic (ca. 175Ma) began to separate Africa from Madagascar/India/Antarctica. The petroleum fairway identified on the MSH is of Middle to Upper Jurassic age (160 – 145Ma, Callovian to Tithonian), and is proposed to comprise Middle Jurassic source rocks deposited in the post-rift sag that are mature and in the oil window and Middle to Upper Jurassic carbonate reservoir rocks deposited on adjacent unrifted shelf areas or rift shoulders. Seals may be intra-formational evaporites, or overlying Cretaceous shales.

Three potential reservoir fairway depositional settings have been identified:

1. A remnant of the original platform that did not actively subside when rifting began, and has remained as a prominent high at the basin margin since the early Cretaceous. Reservoirs are expected to be shelf limestones, possibly dolomitized, comparable to those of the Arabian Platform (Saner & Abdulghani, 1985; Al Awaad & Collins, 2013; Alsharhan, 2014; Gerdes et al., 2010; Wilson, 2020;). Figure 3.

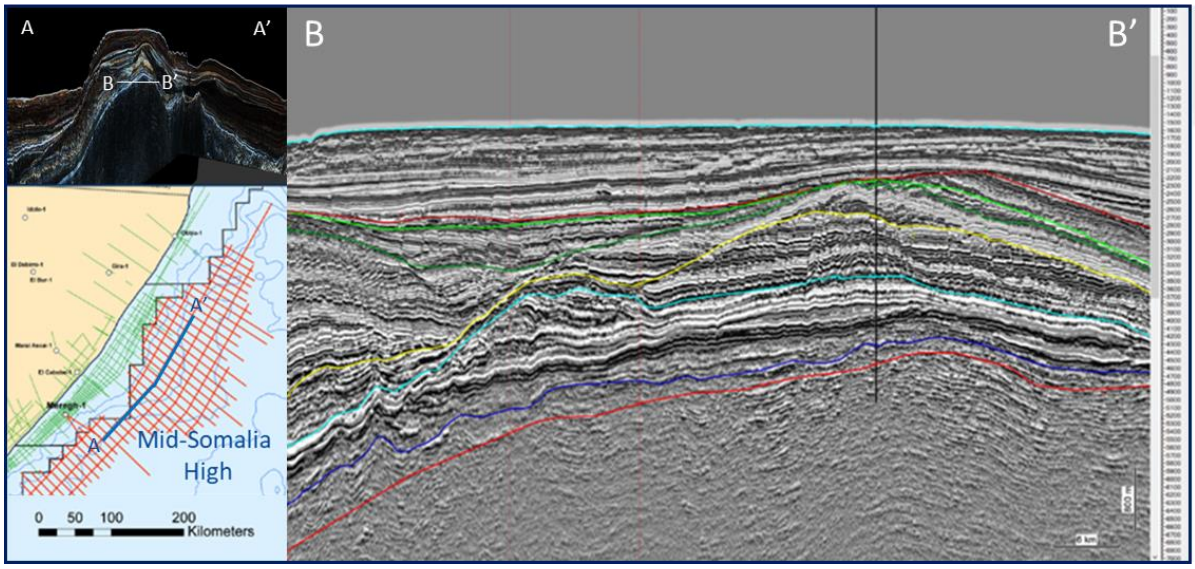

Figure 3 *Line A-A', spectral decomposition attribute across the Mid-Somali High. Line B-B' 2D depth seismic detail of carbonate development between top basement (red, ca. 175Ma and Top Jurassic (yellow, ca. 145Ma)*

2. Carbonate developed on rift shoulders which remained relatively shallow at the edges of the actively-subsiding rift. These may comprise grainstone shoal carbonate facies or biostromal carbonates comparable to the Middle Cretaceous carbonates of the Santos & Campos Basins, Brazil (Muniz & Bosence, 2018; Araujo et al., 2022) and the Kwanza Basin of Angola (Saller et al., 2016). Figure 4.

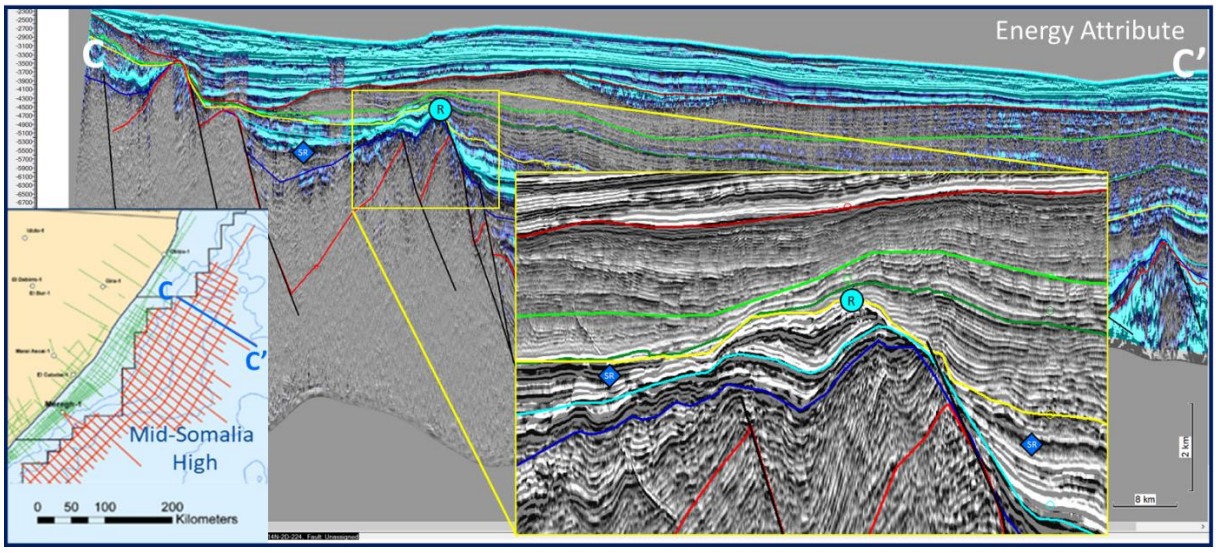

Figure 4 *2D dip line across carbonate developed on a rift shoulder. Main image: calculated "energy" attribute. Insert: reflectivity. R: Reservoir facies; Sr: Source Facies*

3. Redeposited carbonate slope debris eroded as a result of inversion in the latest Jurassic/early Cretaceous and deposited into the deeper part of the rift basin, a play comparable to the Poza Rica trend of Central onshore Mexico (Enos, 1985; Horbury et al., 2005). This fairway is less well-defined on the wide-spaced 2D data available, but recognized on cross-lines by the erosion of the well-laminated Middle Jurassic strata.

References

Al-Awwad, S.F. and Collins, L.B. [2013] Arabian Carbonate Reservoirs: A depositional model of the Arab-D reservoir in Khurais field, Saudi Arabia. The American Association of Petroleum Geologists Bulletin, 97(7), 1099-1119.

Alsharhan, A.S. [2014] Petroleum systems in the Middle East. In: Rollinson, H.R., Searle, M.P., Abbasi, I.A., Al-Lazki, A., and Al Kindi, M.H. (Eds) Tectonic Evolution of the Oman Mountains. Geological Society, London, Special Publications, 392, 361-408.

Araújo, C.C., Madrucci, V., Homewood, P., Mettraux, M., Ramnani, C.W., and Spadini, A.R. [2022] Stratigraphic and Sedimentary Constraints on presalt carbonate reservoirs of the South Atlantic Margin, Santos Basin, Offshore Brazil. The American Association of Petroleum Geologists Bulletin, 106(12), 2513-2546.

Davidson, L.M., Arthur, T.J., Smith G.F., and Tubb, S. [2018] Geology and hydrocarbon potential of offshore SE Somalia. Petroleum Geoscience, 24, 247-257.

Enos, P. [1985] Cretaceous debris reservoirs, Poza Rica Field, Veracruz, Mexico. In: Roehl, P.O., and Choquette, P.W. (Eds.), Carbonate petroleum reservoirs: Springer-Verlag, 28, 457-469.

Gerdes, K.D., Winefield, P., Simmons, M.D., and Van Oosterhout, C. [2010] The influence of basin architecture and eustasy on the evolution of Tethyan Mesozoic and Cenozoic carbonate sequences. In: Van Buchem, F.S.P., Gerdes, K.D., and Esteban, M., (Eds) Mesozoic and Cenozoic Carbonate Systems of the Mediterranean and the Middle East: Stratigraphic and Diagenetic Reference Models. Geological Society, London, Special Publications, 329, 9-41.

Horbury, A., Hernandez, H., Marhx, A., Ojeda, A., Ita, G., and Estrada, J. [2005] Revitalizing the Poza Rica Field: New Insights into the Tamabra Reservoir and a Tale of a Paradigm Lost. American Association of Petroleum Geologists Search and Discovery Article 20027.

Muniz, M.C., and Bosence, D.W.J. [2018] Lacustrine Carbonate Platforms: Facies, cycles, and tectonosedimentary models for the presalt Lagoa Feia Group (Lower Cretaceous), Campos Basin, Brazil. The American Association of Petroleum Geologists Bulletin, 102(12), 2569-2597.

Saller, A., Rushton, S., Buambua, L., Inman, K., McNeil, R., and Dickson, J.A.D. (Tony) [2016] Presalt Stratigraphy and depositional systems in the Kwanza Basin, offshore Angola. The American Association of Petroleum Geologists Bulletin, 100(7), 1135-1164.

Saner, S., and Abdulghani, W.M. [1995] Lithostratigraphy and Depositional Environments of the Upper Jurassic Arab-C Carbonate and Associated Evaporites in the Abqaic Field, Eastern Saudi Arabia. The American Association of Petroleum Geologists Bulletin, 79(3), 394-409.

Scotese, C.R. [2001] Atlas of Earth History PALEOMAP Project, Department of Geology, University of Texas at Arlington

Wilson, A.O. [2020] Introduction to the Jurassic Arabian Shelf Basin. In: Wilson, A.O., The Middle and Late Jurassic Intrashelf Basin of the Eastern Arabian Peninsula. Geological Society, London, Memoirs (53) 1-19.