# *An Introduction to Future Prospectivity in the MSGBC Basin*

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Sufficient understanding is now available from wells, seismic and geochemical studies to meaningfully assess the future pattern of discoveries in the MSGBC Basin. The most encouraging new advance is the identification of basin wide, frequently mature multiple source horizons, including now proven new sources deeper than the Cretaceous. The traditional known sources are in the Aptian to Turonian interval of the Cretaceous with the most quoted, type sections located in DSDP coreholes 367 and 368. However, hydrocarbons have not been unequivocally typed to this interval, at least in the public domain. In recent years the Lower and Middle Jurassic have emerged as a second regional source. Direct typing to this source is not possible due to the depth of the host beds in the MSGBC Basin, though equivalent horizons are present in Suriname and Morocco. Despite this, the environment biomarkers associated with the Jurassic sourced oils support an origin from the predicted facies that accumulated during the rift to drift transition. Most oil and gas appears to be a mixture of both sources. Where the Cretaceous is immature, Jurassic oil opportunities also exist. Where it is mature, Jurassic gas will also be present. An exception exists in northern Senegal and southern Mauritania where a combination of kerogen types within the Mid-Cretaceous source interval, higher heat flows related to Cainozoic magmatism, and the depth of burial of the Cretaceous predispose this region to gas generation at all levels.

Jurassic sources are missing in South East Guinea, as this region was not affected by Central Atlantic rift events (see Figure 1 below). Mid-Cretaceous sources are present, but less is known about their quality here than to the north. Encouraging are shelf located slicks and the wet gases in wells. These sources are effective in Sierra Leone.

Clastic reservoirs

As is the case everywhere in West Africa, the greatest potential lays ocean-wards of the major river entry points. By far the largest entry point in the MSGBC Basin is the Casamance Delta that was extinguished at the end of the Cretaceous, and in particular its northern Tamna Arm (Figure 1). Since sand to shale ratios increase shorewards, the largest clastic opportunities lie in deepwater BFFs encased within thick, river fed shales (another reason why major rivers are so important). This is where Kosmos have made their giant gas discoveries. These lie within the Albian and Cenomanian portion of the Tamna Arm. Future developments in this region will depend on how the properties of the two source intervals change away from the Tamna Arm depocenter.

The ‘prospectivity’ of central and northern Mauritania may be limited due to the volume of available sand, but could be enhanced in BFF foci. A wildcard is the mixed clastics and carbonates of the Ras al Baida region of northern Mauritania, though top seal may be problematic across the high. North East Trade wind blown sands supplied from the Sahara may bulk up reservoir volumes in focus regions.

Traps in this commonly little structured region will be stratigraphic. Salt provides traps updip in shelf and slope settings, but its mobile behaviour complicates their geometries. Miocene pay is present above salt at Chinguetti.

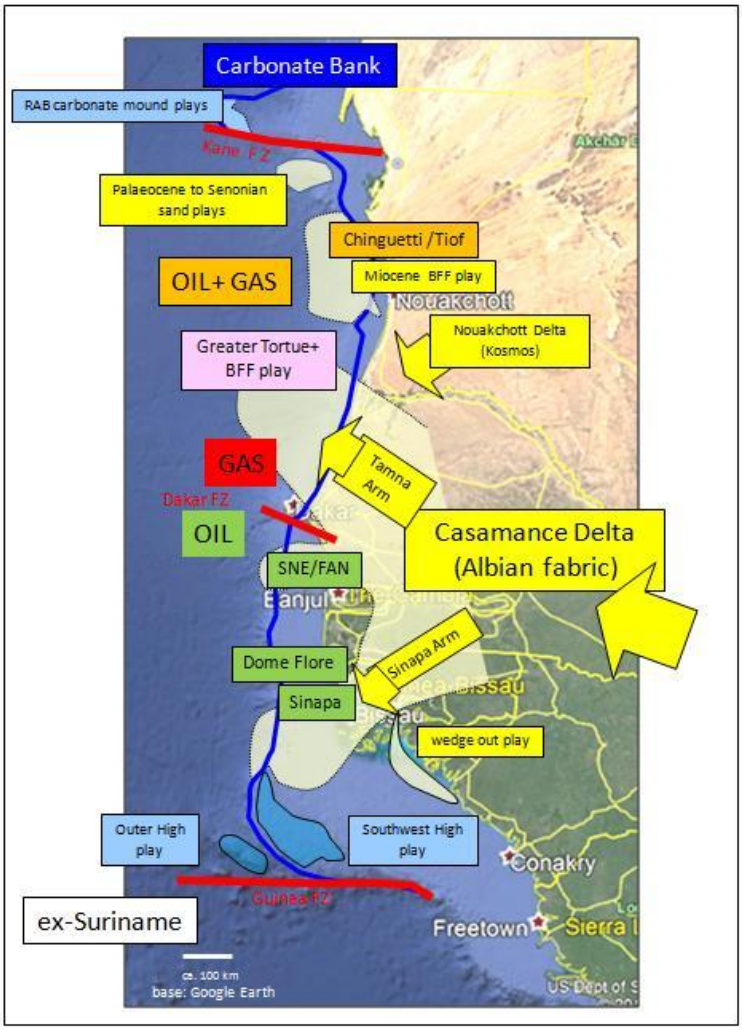


*Figure 1. Plays.*

A critical exception to these generalities exists in the SNE region of southern Senegal where former shelf edge, Albian and Cenomanian sands are associated with a southern lobe of the Tamna Arm of the Casamance Delta. These sands are thick and capped by source-bearing shales. The sources are oil-prone as they lie south of the Tamna Arm depocenter and are in the Oil Window, both off shelf to the west and possibly also landwards to the east. Such areas likely also exist elsewhere in the MSGBC, but they will only function where downcutting, younger Cretaceous sand interbeds related to the Santonian Break have not breached the reservoirs. Obvious immediate areas of interest on the shelf are on-trend to SNE, both to the north and to the south.

To the south one such area is being tested in The Gambia by FAR with their Samo-1 well. To the north a play variant involving now proven Lower Jurassic sourced oil is also located (now onshore) within Fortesa's acreage. Production so far in this region is from Santonian Break associated reservoirs deposited in inter-slope settings, where volumes so far are small. In reference to the kerogen type deposited and the

thermogenic nature of these new deeper source rocks: gas, condensate and oil are predicted by FEC's work to be present.

The SNE discoveries also require that off-shelf, Albian and Cenomanian sands exist in the FAN region. How much oil will be found will depend of the westwards extent of maturity within the mid-Cretaceous and the relationship of opportunities to the Lower Jurassic kitchen.

A second major arm of the Casamance Delta exited though Guinea-Bissau. This is the Sinapa Arm and is the site of the non-commercial Sinapa Oil Field. Targets are limited by trap complexity, leakage and, because of reservoir damage caused by diagenesis associated with suspected hot fluids, permeability. These fluids would have escaped from the salt domes and deep cutting faults, such as those defining the tested tilted fault blocks. In-place oil volumes are large and the Sinapa region remains of serious interest. Stratigraphic traps, for example channels located away from the structures, may offer the best future opportunities. Gas chimneys associated with the updip wedge out succession positioned close to the coast suggest further new plays exist. As these areas are in a high sand net to gross region, the traps may be leaking at rates related to the charge rate. A Paleozoic source for the gas chimneys cannot be fully discounted.

Southern Senegal and much of the AGC lies between the two Casamance Delta lobes and appears to be sand poor at the Albian and Cenomanian levels, but Mid-Cretaceous and Jurassic aged source rocks are present: these together sourced the Domes Flore and Gea, giant heavy oil finds. The best opportunities for live oil probably lie in the younger Cretaceous. However, traps involving these sands close to the diapirs may have similar complexity to Sinapa. Better results may come from off-dome, stratigraphic traps, given proper charge. The geology in the west of this region is further complicated by allochthonous salt and shelf edge collapse; Kora-1 was located in this region.

Guinea lies to the south of the influences of the Casamance Delta and its geology is determined by Equatorial Atlantic rifting events. Turonian and Campanian (Cretaceous) sands are developed, but sand volumes may limit clastic opportunities since there is no firm evidence for major river exits in this region.

<u>Carbonate reservoirs</u>

Commonly referred to as carbonate bank, shelf-edge opportunities, the Jurassic to mid Albian carbonates have and continue to be targets along both margins of the Central Atlantic. Apart from one field in Nova Scotia (Canada), they have been unrewarding commercially. The reasons may lie in the difficulty of predicting carbonate facies from often indifferent seismic. In early 2018 ExxonMobil made a carbonate discovery in deepwater Guyana.

Modern seismic, processing and software may be able to better determine reservoir horizons. Segments of the shelf edge carbonates were eroded during the Cretaceous and in these areas the remnant carbonate bank is difficult to track seismically. This is especially true beneath the Tamna Arm of the Casamance Delta. Bank edge targets are everywhere optimally located to receive both laterally and

vertically migrating hydrocarbons in the same way that the SNE discoveries are now proven to be. Equivalent plays are highly productive along the north side of the Gulf of Mexico and to the south in Mexico.

Most interesting of the classic target regions is the Rufisque Dome structure to the south of Dakar (Senegal) where cavernous porosity is developed in a region that is favourably located, because of the proximity to the intrusives of the Cenozoic Dakar Dome, for the formation of hydrothermal dolomites. Apparent hydrothermal alteration of the clastic cover section to the Dakar Dome is present at outcrop.

2018 work by FEC suggests that Aptian and Albian carbonates are widely present across the central Guinea Marginal Plateau (GMP) in both Guinea-Bissau and Guinea to the south of influences from the Casamance Delta. Little is known about them due to the absence of industry wells, though a crucial, academically obtained rock sample exists. Large multi-horizon, low relief traps are developed. Carbonate factory, shelf facies are suggested. The closures are developed above mobile Jurassic salt, some of which was driven northwards by sediment loading to escape to form the diapirs in the Sinapa region. The hot fluids thought to be causing the previously noted reservoir damage in this region may have been expelled at that time.

A major collapse structure, the Outer High, lies to the south west of the Plateau. Intense fracturing, thought to been formed during the rebound of the shelf edge following the detachment of the Outer High, characterizes the adjoining portion of the Guinea Marginal Plateau. The carbonates are unconformably covered by post-collapse, thick, sealing shales. Acoustic impedance properties of the carbonates suggest cavernous porosity created by subaerial exposure during the cutting of the unconformity is developed.

Though the Mid-Cretaceous sources south of the Sinapa region are modelled to be immature, the underlying Jurassic is considered to be mature. FEC's interpretation and integration of piston core geochemical direct detection results of the TDI-Brooks piston core samples confirms that oil and gas are widely present, where otherwise there is no modelled Mid-Cretaceous maturity. This carbonate-bearing region of the Guinea Marginal Plateau is regarded by FEC as the next major frontier for the MSGBC Basin. Expected developments elsewhere are summarised in Figure 2.

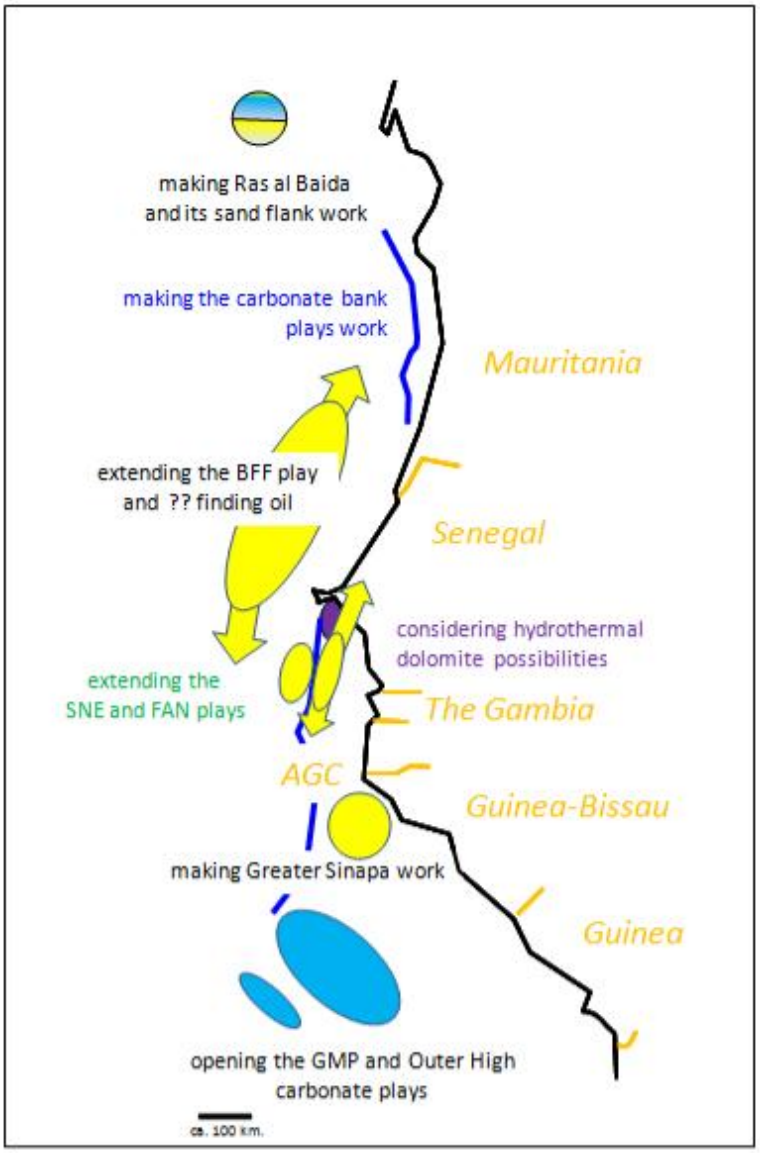


*Figure 2. FEC's Expected **'Coming MSGBC Developments'**.*

Collectively the sum volume potential is estimated to be at least as large as the recent major discoveries in Senegal and Southern Mauritania. Comprehensive information on the play potential of the MSGBC Basin may be obtained from First Exchange Corporation whose contact details are provided below.



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