

Deepwater hydrocarbon prospectivity analysis of offshore North and South Gabon Basin

Muhammad S Tamannai^(*), Thomas Hansen⁽¹⁾, Ron Borsato⁽¹⁾, Jennifer Greenhalgh⁽¹⁾

Martial-Rufin Moussavou⁽²⁾ & Landry Olouchy Essongue⁽²⁾

⁽¹⁾Petroleum Geo-Services

⁽²⁾Direction Générale des Hydrocarbures (DGH) Gabon

Summary

This study addresses the hydrocarbon prospectivity analysis of the offshore Gabon region comprising the North and South Gabon Basins based on interpretation of merged 3D seismic surveys and well data. It describes the geology, structure and hydrocarbon potential of the offshore Gabon basinal area.

Introduction

Gabon is situated in the west coast of Africa (figure 1) bounded by Cameroon, Equatorial Guinea, Congo and the Atlantic Ocean. Oil and gas exploration in Gabon dates back to the 1920s with the first commercial discovery, the Ozouri field, which was made by Elf and brought on-stream in 1956. Between then and the late 1990s a large number of oil and gas discoveries were made both onshore and offshore making Gabon Africa's eighth largest oil producer. Production has long been established from the pre-salt section onshore and in shallow water offshore but this has not yet been extended to the deeper water offshore.

This study highlights prospectivity in both pre- and post-salt sections in the deeper offshore.

The pre-salt section is structurally complicated and has been difficult to image seismically whereas less geological complexity and deformation in the post-salt section has enabled better seismic imaging of the younger section.

The Gabon Basins are located in the larger Aptian Salt Basin of Equatorial West Africa, part of the pan-regional salt basin complex that stretches from southern Cameroon in the north to Namibia in the south, limited to the north by Guinea Ridge and to the south by the Walvis Ridge. Both of these bounding ridges are volcanic basement features.

The Gabon Basins consist of three sub-basins; the North Gabon, South Gabon and Interior basins (figure 2), each of which has a different geological history.

These basins were initiated during the rifting phase as the Atlantic opened, and developed further during the post-rift/sag phase. The basin fill is divided into three major sedimentary megasequences; the pre-rift, the syn-rift and the post-rift megasequence.

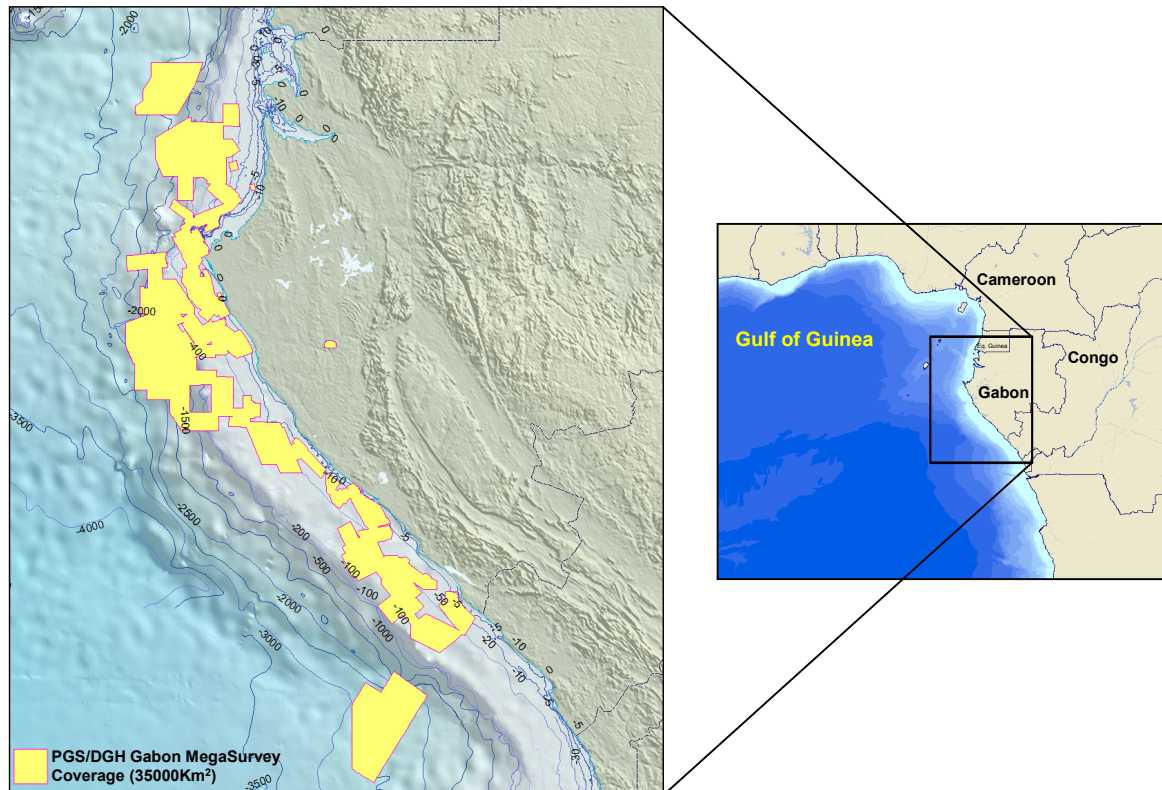


Figure 1: Location and bathymetry of the study area

Offshore Gabon HC prospectivity analysis

To date pre-rift rocks have only been encountered onshore along the eastern flank of the Interior Basin where they are up to 600m thick and comprise continental, fluvial and lacustrine sediments of Carboniferous to Jurassic age (Teisserenc and Villemin, 1990). No pre-rift sediments have been penetrated in either the North or South Gabon Basins, onshore or offshore. In Gabon, the onset of rifting started during Neocomian–Berriasian times (144M years ago) (Uchupi, 1989; Binks and Fairhead, 1992; Guiraud and Maurin, 1992) and led to the formation of an extensional fault system forming a series of graben and horst structures within which the Gabon sedimentary section is deposited above metamorphic basement complexes. The oldest syn-rift sediments encountered in Gabon are found in the Interior Basin onshore, which is separated from the offshore basinal areas by the Lambarene Horst. The end of the rifting here has been dated and is associated with magnetic anomalies that suggest that the rift duration can be approximated to about 25M years.

Gabon is segmented by NE-SW trending strike slip faults defining zones with different tectonic and stratigraphic histories. The N’Komi fracture zone divides the North and South Gabon basins.

Post-rift rocks range from Aptian to Holocene in age and represent the sag & drift phases following opening of the Atlantic as equatorial West Africa spread away from South America. The initial post-rift rocks are of early to mid-Aptian age and consist of continental, fluvial and lagoonal rocks deposited as rifting ceased, followed by a period of extensive accumulation of evaporite units. Younger post-rift rocks were deposited in two distinct regimes; transgressive units consisting of shelf clastic and carbonates followed by progradational units along the continental margin and open-ocean basinal units

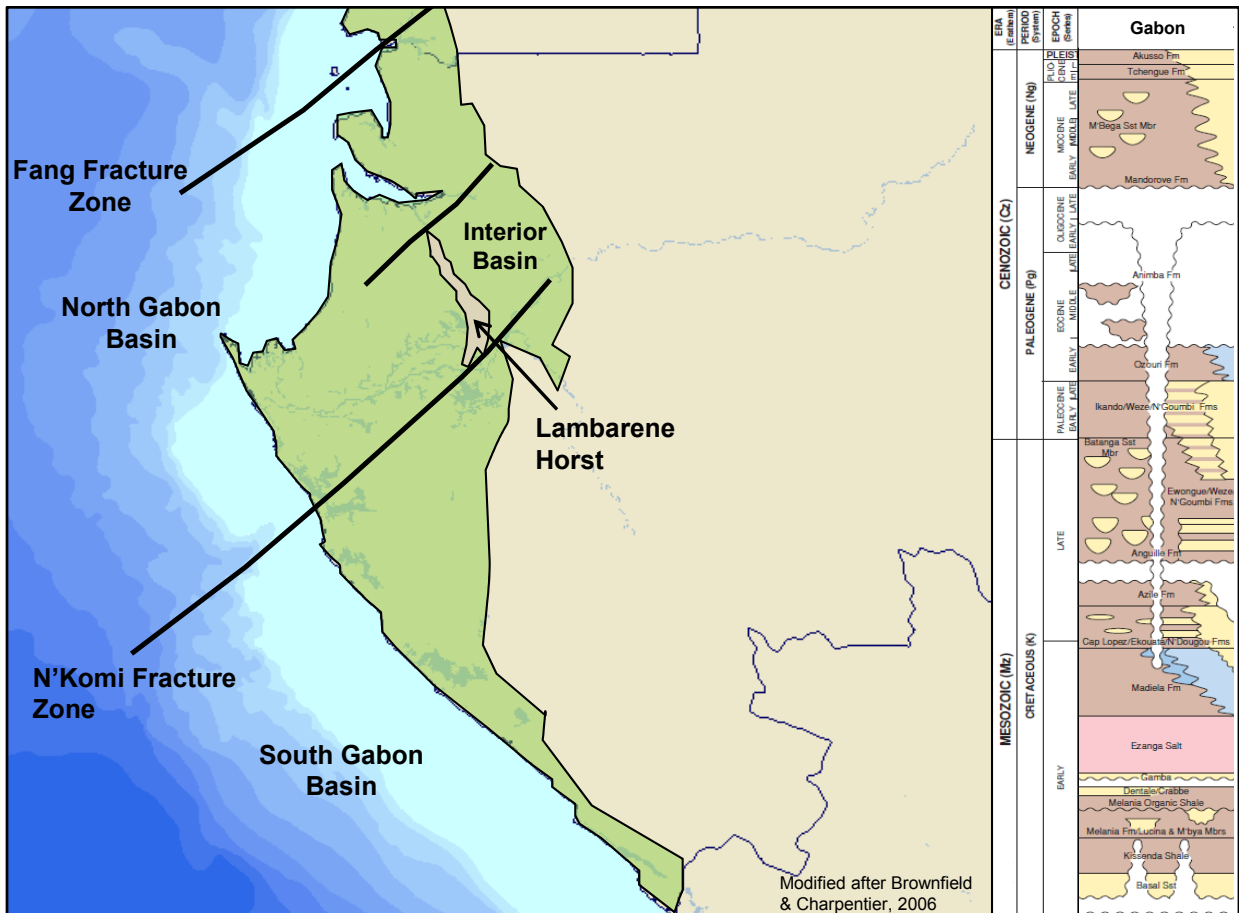


Figure 2: Regional tectonic elements and stratigraphy of Gabon

Offshore Gabon HC prospectivity analysis

Prospectivity Analysis

Numerous structural and stratigraphic traps from offshore Gabon have been identified and evaluated during this study.

Figure 3 shows a seismic section from the North Gabon Basin demonstrating pre- and post-salt hydrocarbon trapping styles. The post-salt section of North Gabon Basin is dominated by stratigraphic trapping mechanisms. They are sometimes incorporated in 4 way dip closures directly above the salt domes and include channel/fan systems. These channels can easily be identified on seismic data as well as on various attribute maps. The meandering channel geometries can be mapped into deeper waters where they terminate in deep offshore turbidite fans.

In addition to the post-salt prospectivity, pre-salt sediments also offer good exploration potential in the form of stratigraphic and structural (mainly fault blocks) traps. These traps are effectively sealed by overlying salt (where it is present) and are likely to be charged from pre-salt source rocks which have been proven to be mature for oil

and gas generation in this area to make an effective petroleum system.

Figure 4 is a seismic section taken from the South Gabon Basin and shows multiple types of traps within the pre- and post-salt sedimentary sections. The indicated interval identified and mapped below the salt, is considered to be part of the Gamba Formation which includes fan/channel sandstones. The Gamba Sandstone is a well known reservoir unit offshore Gabon and discoveries, for example the Etame Field, have been made within this unit. Additional deep, tilted fault blocks have been identified with brighter seismic amplitude character suggesting potential sand presence and possible DHIs. These sands are thought to be of the Dentale Formation which is a proven reservoir in the shallower water regions.

Post-salt sediments offer additional potential in form of a variety of trapping styles including 4-way dip closures, potential carbonate traps and stratigraphic pinch-outs. Brighter seismic amplitudes observed in the post-salt section may indicate the presence of hydrocarbons.



Figure 3: Interpreted seismic section from North Gabon Basin showing pre- & post-salt potential traps

Offshore Gabon HC prospectivity analysis

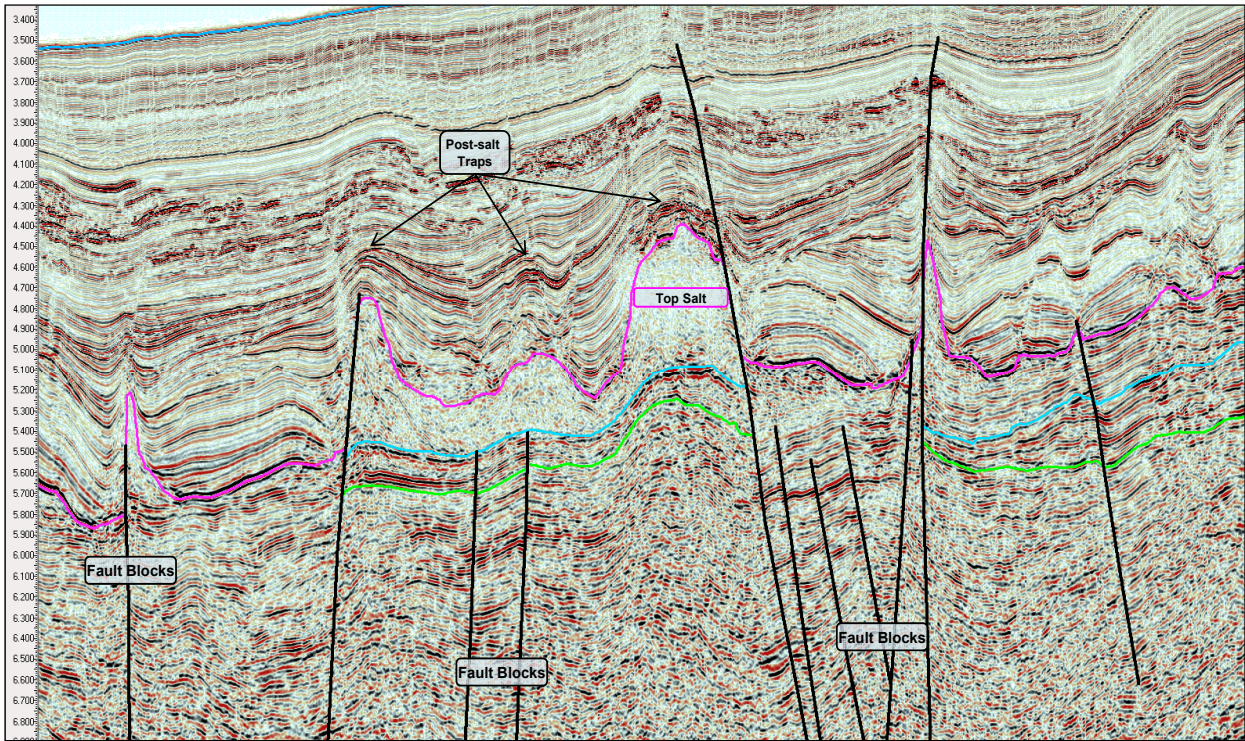


Figure 4: Seismic section from the South Gabon Basin showing various types of hydrocarbon trapping mechanisms

Conclusions

Pre- and post-salt sediments have been found potentially prospective within the North and South Gabon basins. A variety of structural and stratigraphic traps of various sizes have been identified and evaluated.

Deepwater hydrocarbon prospectivity of the North and South Gabon Basins can be summarized as:

- Post-salt existing discoveries are primarily related to closures over salt features.
- A number of meandering channel features with abandoned cross-cutting and oxbow geometries have been identified in North Gabon Basin. The changes in geomorphology are related to channels altered their paths because of the underlying salt withdrawal.
- New potential reservoir targets identified during this study include Post-salt carbonate traps associated with brighter seismic amplitudes & well developed deep-water channel and fan systems.

- Stratigraphic and/or structural traps in pre-salt sediments can also be identified, especially in the South Gabon Basin. These have the potential to contain significant quantities of hydrocarbons – as has proved the case elsewhere along both the Brazilian and West African margins of the pan-regional salt basin. The majority of these targets are located within the Gamba and Dentale Formations and offer the potential for stacked reservoirs.

Acknowledgements

We would like to thank Petroleum Geo-Services and Direction Générale des Hydrocarbures Gabon for allowing us to publish this paper and to other colleagues for their help, support and reviews during this study.

EDITED REFERENCES

Note: This reference list is a copy-edited version of the reference list submitted by the author. Reference lists for the 2013 SEG Technical Program Expanded Abstracts have been copy edited so that references provided with the online metadata for each paper will achieve a high degree of linking to cited sources that appear on the Web.

REFERENCES

- Binks, R. M., and J. D. Fairhead, 1992, A plate tectonic setting for Mesozoic rifts of west and central Africa: *Tectonophysics*, **213**, 141–151.
- Brice, S. E., M. D. Cochran, G. Pardo, and A. D. Edwards, 1982, Tectonics and sedimentation of the South Atlantic rift sequence, Cabinda, Angola, *in* J. S. Watkins, and C. L. Drake, eds., *Studies in continental margin geology: AAPG Memoir* **34**, 5–18.
- Edwards, A., and R. Bignell, 1998a, Hydrocarbon potential of W. African salt basin: *Oil & Gas Journal*, **86**, no. 51, 55–58.
- Guiraud, R., and J.-C. Maurin, 1992, Early Cretaceous rifts of western and central Africa — An overview: *Tectonophysics*, **213**, 153–168.
- Lambiase, J. J., 1989, The framework of African rifting during the Phanerozoic: *Journal of African Earth Sciences*, **8**, no. 2/3/4, 183–190.
- Lehner, P., and P.A.C. De Rittler, 1997, structural history of Atlantic margin of Africa: *AAPG Bulletin*, **61**, no. 7, 961–981.
- Teisserenc, P., and J. Villemin, 1990, Sedimentary basin of Gabon geology and oil systems, *in* J. D. Edwards, and P. A. Santogrossi, eds., *Divergent/passive margin basins: AAPG Memoir* **48**, 117–199.
- Uchupi, Elezar, 1989, The tectonic style of the Atlantic Mesozoic rift system: *Journal of African Earth Sciences*, **8**, no. 2/3/4, 143–164.
- Ziegler, D. G., 1988, Early Mesozoic plate reorganization, *in* D. G. Ziegler, eds., *Evolution of the Arctic — North Atlantic and Western Tethys: AAPG Memoir* **43**, 43–61.