

The Angle of the North

Shallow water oil is hidden in plain sight in North Gabon.

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The 5,000 km² of open acreage in shallow water off North Gabon sits adjacent to the site of one of the biggest discoveries in the world in 2014 – ENI’s Nyonie-Deep discovery. One might expect that such a discovery would have made the surrounding acreage incredibly highly sought-after. Actually this area now suffers from one major drawback – the Nyonie-Deep discovery.

The issue at first glance is that Nyonie-Deep discovered gas in pre-salt syn-rift Dentale formation sandstone (locally called Coniquet Sandstone) that has low permeability. Gas in itself is not the hydrocarbon of choice in Gabon, which is at an early stage in its development of a gas export system, and the meme has grown from this discovery that the pre-salt of North Gabon is tight and gas prone. Nyonie redeems itself commercially by being a very large accumulation, estimated at 500 MMboe – and ironically gas is the only fluid producible from such low permeability sands.

So does this really write-off the whole of the pre-salt of North Gabon as being gas prone and tight? We argue absolutely the reverse – the pre-salt plays in the open acreage are likely to be oil-bearing in good quality sandstone. Our confidence in this model is such that Spectrum will undertake a 5,500 km² 3D survey over the open area in 2017. So what angle do we work here? Firstly, variable heat-flow and source rock maturity can be evaluated to support the case for oil and secondly, despite the exploration immaturity and sample bias

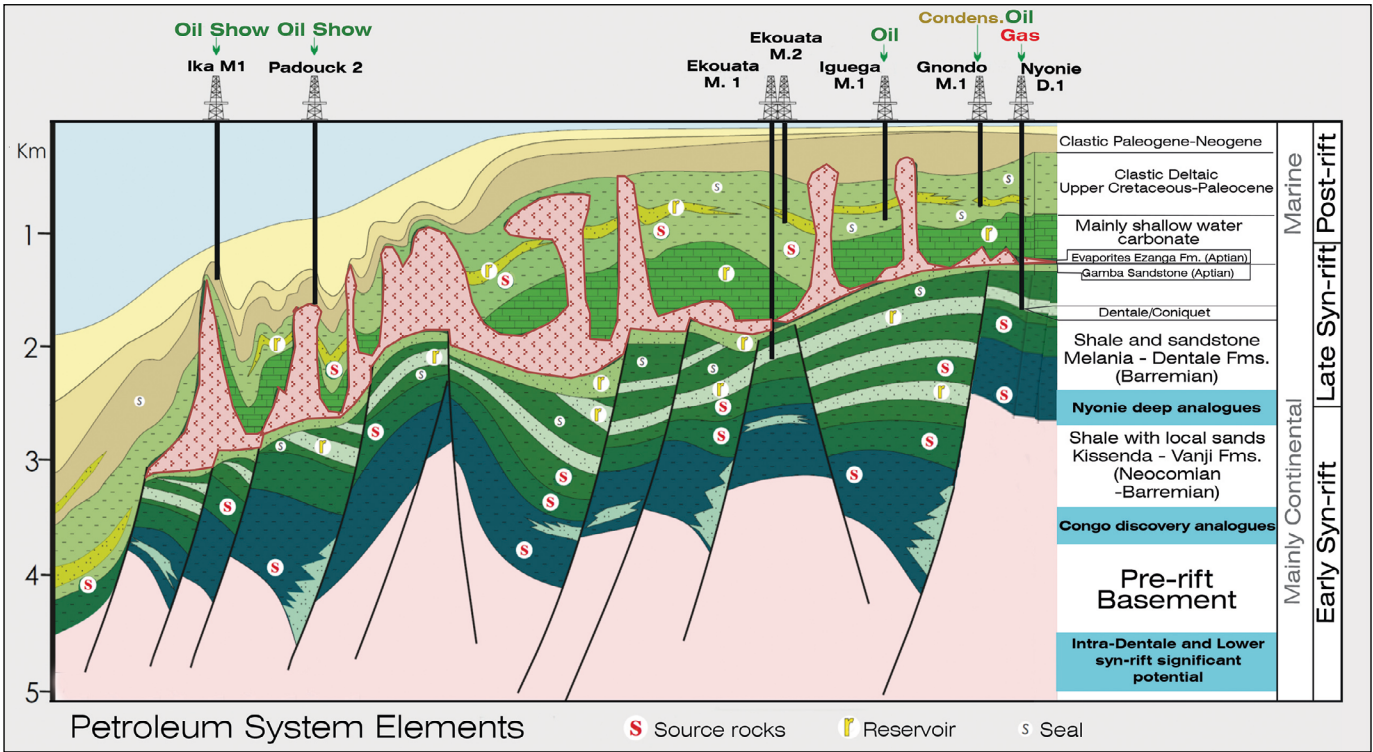
of the area, we believe that Nyonie-Deep has poor reservoir due to localized inversion. Bringing these two considerations to bear opens the probability that this unexplored area is ready to yield major surprises in the next wave of exploration.

Exploration Plays in North Gabon

As the figure below shows, traditionally two apparently separate systems are considered in North Gabon: a pre-salt syn-rift system with the lacustrine Melania and Kissenda source rocks, charging syn-rift Dentale fluvio-deltaic sands; and post-rift transgressive Gamba sandstone formation. An additional source rock, the restricted marine Vembo shale, is ubiquitously encountered sitting above the transgressive Gamba sandstone. Above the salt lie a number of deltaic clastic reservoirs such as the Ewongue, Anguille, and Cap-Lopez Formations, in drapes, turtle structures and stratigraphic traps generated by salt topology.

What is very clear on seismic is that the distribution of salt is very heterogeneous across the area. In the east it is very thin, or restricted to vertical diapirs, representing a salt body that has been mobilized by sediment loading, reactive fall withdrawal and gravity sliding, creating a clastic- (and to the east carbonate-) rich section. To the west, however, the salt is still present in extraordinary amounts as complex salt walls, domes, canopies and diapirs. As we shall see, this

Sketch of hydrocarbon trapping systems of North Gabon.



heterogeneous distribution is crucial for exploration.

The Case for Oil

The map of exploration wells drilled to date in the area adjacent to Nyonie shows that some 16 wells have been drilled in this open acreage. However, out of all these wells, only two have drilled into the pre-salt. Previous exploration strategies have targeted the post-salt section, where several oil discoveries (GLK-1, Iguega and Equata) were made. The post-salt is the dominant play system in the prolific Ogooue delta to the south, where there are a number of post-salt source rocks which can be buried deep enough – or with a high enough geothermal gradient – to generate oil.

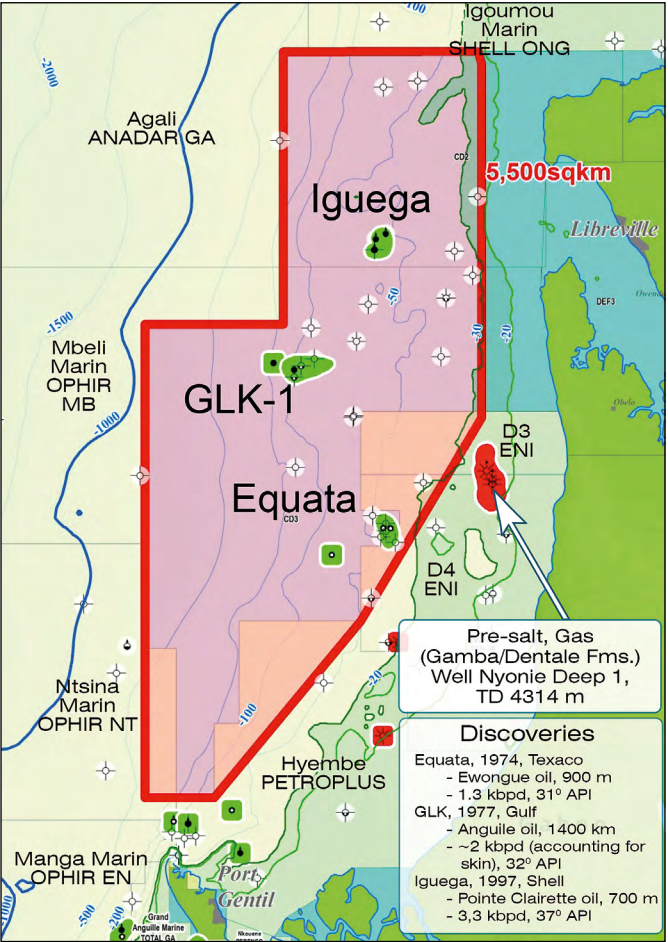
However, analysis of wells drilled in this region have revealed a number that have sported oil shows and sampled oil in horizons that lie stratigraphically below the lowest of the post-salt sources, requiring either complex downward migration or, more simply, demonstrate that oil is being generated in the pre-salt.

At first sight this is surprising as the Nyonie well entered the pre-salt at some 4,000m, where the geothermal gradient to the surface averages 33°C/km, and one expects the depth to the syn-rift to increase going west. So if the syn-rift source rocks under Nyonie were hot enough to generate gas, how could the same sequence be generating oil to the west? The answer to this may be the distribution of thick bodies of salt to the west, as the salt is a better conductor of heat than clastic wedges, so the presence of salt will cool the underlying syn-rift, and draw heat to heat up the overlying post-salt section. Available data on pre-salt geothermal gradients show that the pre-salt to surface gradient can be as low as 22°C/km in the west adjacent to thick salt. Whilst this aids the maturity of post-salt source rocks, it will retard the maturity of the syn-rift Melania and Kissenda source rocks, leaving them in the oil window.

Reservoir Complexities

Although the number of penetrations of the pre-salt is a fraction of that in South Gabon, there is enough core data to show that porosities in the pre-salt of North Gabon range from 5–20%, and permeabilities from 1–700 MD. This range is similar to that in South Gabon, although based on far fewer penetrations. There may also be some sampling bias, as the Nyonie poroperm is relatively poor, reflecting a different style of structure drilled so far in the north compared to South Gabon. In the south the prolific Gamba is the main target for exploration. This sandstone was deposited during the peneplanation of the first marine transgression of post-rift, eroding and reworking the upper parts of rotated Dentale Formation fault blocks. As such, the Gamba sands of South Gabon have never been buried and uplifted and consequently retain good poroperm characteristics.

However, the Nyonie-Deep structure comprises a large inverted fault block complex. The crest of this block was eroded significantly by the Gamba transgression, so that the Dentale reservoir is old, inverted and poor quality. Introduction of poroperm data from the inverted Nyonie reservoir introduces sampling bias to the analysis of this North Gabon acreage. The key to exploration of the pre-salt



Exploration density to date. Red shaded area is Spectrum's proposed 3D area.

to the west of Nyonie is that the syn-rift fault blocks are less inverted and eroded, so that the Dentale can be expected to be better quality, with higher porosity and permeability, and the Gamba and Vembo Shale units will be thicker too.

Exploration Potential

Exploration of the pre-salt of North Gabon west of Nyonie has barely started, yet from the few penetrations to date we see good evidence for a working oil syn-rift system and are confident that good quality reservoir can be predicted in significant little eroded fault blocks and overlying units. The increase in presence and thickness of salt to the west has reduced the geothermal gradient locally to keep the Melania and Kissenda source rocks in the oil window.

Further west, into the salt domain, the post-salt sequences are very thick and complex and have not been fully explored due to the complexities of imaging plays even with early 3D data. The pre-salt systems may be working and even the post-salt provides attractive targets as the post-salt source rocks are likely to be generative.

Spectrum's exploration angle is the driving force that will lead it to acquire 3D in North Gabon in the next few months. This new coverage with long streamer 3D designed to image the pre-salt will unlock the potential of this overlooked play system. The future for exploration in North Gabon is bright and offers the promise of shallow water oil of a resource magnitude that is hard to find anywhere in West Africa. ■