Liberia
A Fresh Approach

New thinking inspired by innovative modelling could open new plays in West Africa.

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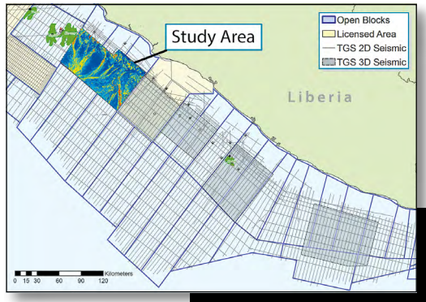
Recent exploration in Liberia has not provided the commercial success we all want, with the most recent well, Mesurado-1 (drilled by ExxonMobil in Block 13 in approximately 2,500m water) coming up dry. TGS feel that history is repeating itself with stratigraphic traps with strong AVO support being drilled and not producing a success. There is a working petroleum system, proved by sub-commercial discoveries, and Mesurado-1 provided a much needed boost to the understanding of reservoir quality, as 118m of good quality Santonian were logged (COPL press release, 19 December 2016). With all the pieces of the play puzzle in place, TGS has decided a fresh approach is needed to prospectivity hunting and has therefore begun a new wave of interpretation of the seismic data to help solve the puzzle and unlock the treasures buried offshore.

TGS has partnered with NOCAL (National Oil Company of Liberia) for over 15 years and has built up a comprehensive seismic database with over 34,000 km 2D and 24,500 km^2 3D seismic. The company is committed to working with the excellent exploration team in Monrovia to help deliver the hydrocarbon response so eagerly anticipated. The first step of the reinvigoration of geological and geophysical analysis is to work with Lyme Bay Consulting, taking a data driven approach to leads and prospect identification.



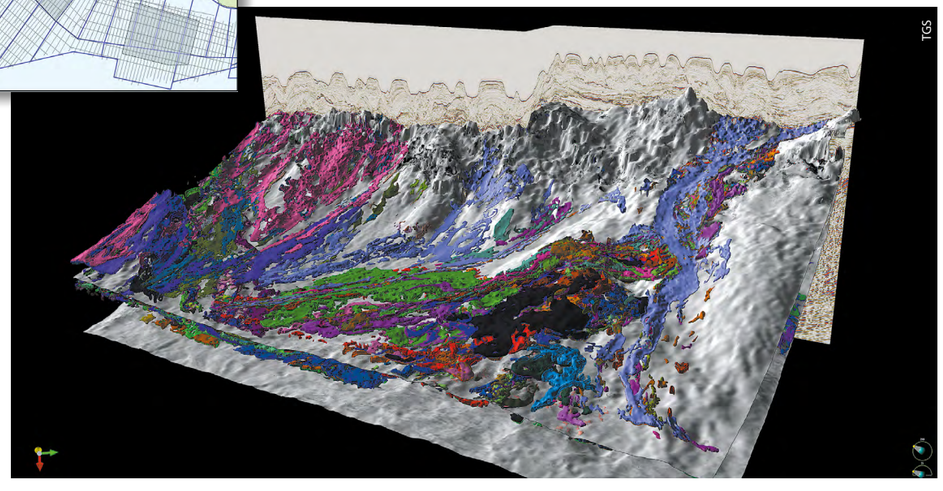


Figure 1: A geobody extraction highlighting extensive channel complexes overlain on the Top Cretaceous surface.

Detailed Reconnaissance Study

There are two known distinct hydrocarbon systems (Early and Late Cretaceous) within offshore Liberia (Bennett et al., 2002). Initial exploration demonstrated the potential for an Early Cretaceous petroleum system consisting of Apto-Albian marine and lacustrine shales, although the Late Cretaceous system has received more attention in recent years. This consists of Late Cenomanian to Turonian marine shales deposited throughout the central and southern Atlantic during a global anoxic event. Although missing in shelf wells, this sequence is characteristically organic-rich throughout offshore west Africa.

Trap types within this system are confined to stratigraphic channels and fan systems, a few of which have been delineated by the work undertaken by Lyme Bay Consulting, who applied their Detailed Reconnaissance Study (DRS) workflow to the pre-stack time migrated 3D volume and associated angle stack volumes from Blocks 15, 16 and 17 in northern Liberia, as shown in the inset to Figure 1. The DRS builds a 'GeoModel' based on the underlying seismic data, and calculates and correlates the relationship between 3D seismic events according to the similarity of the wavelets and their distance from each other. The DRS produces a horizon-consistent map for each and every reflector within the dataset. Attributes are then calculated from the original seismic and overlain on the horizons to deliver a high-resolution reconnaissance tool to enable identification of structural and stratigraphic features within the data. Two hundred horizons were generated for this initial pilot study, which TGS will be using to seed the next wave of interpretation and exploration in Liberia.

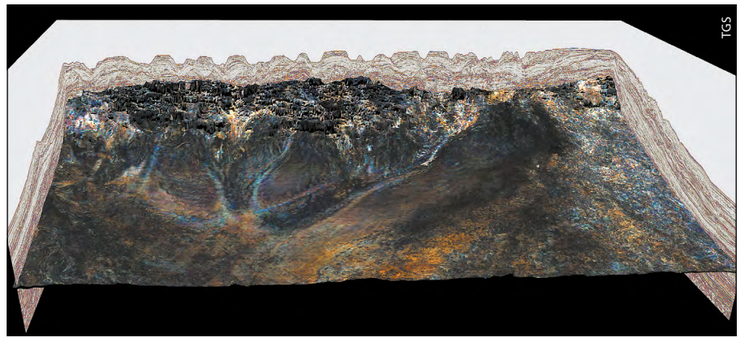


Figure 2: A spectral decompositon surface showing Late Cretaceous canyons feeding a basin floor fan.

Geobody Examples

During the DRS work, geobodies were extracted from the data to highlight submarine clastic channel complexes and turbidite systems shedding into the basin from the shelf margin (Figure 1). Attribute volumes were created and analysed including Structurally Oriented Semblance/Coherency, Frequency Decomposition (Figure 2) and Reflectivity Data Amplitudes for the full and partial-angle stack data. The quality of the TGS input data was highlighted in the initial results, with excellent frequency content proving very valuable even at depths of greater than seven seconds.

Figure 2 shows a spectral decomposition indicating an example of an Upper Cretaceous stacked fan system being fed from channels on the shelf through canyons downslope to palaeo-basin floor. In total, the DRS has identified over 96 separate channel features from Early Cretaceous syn-rift to Tertiary post-rift. These regional channel and fan complexes have been mapped across the entire 3D study area, with the seismic imaging allowing delineation of multiple stacked systems, all highlighting the excellent reservoirs waiting to be unlocked.

AVO analysis has a lot to answer for in the Liberian Basin, as brightening with offset does not consistently appear to indicate hydrocarbons in this basin. It is possible that a sequence stratigraphic approach would be more beneficial, allowing for traditional geological prediction of plays when searching for drill locations. Integrating this knowledge with the data-driven results provided by the DRS, which in this study highlighted an abundance of braided channels, fan splays and levee complexes, will allow a more intelligent way to discern which sands to drill and which to leave alone.

Gerrard Spear, Geoscience Director at Lyme Bay, said that this DRS analysis is one of the best his company have ever worked on, with the seismic data exhibiting "an embarrassment of riches, with an awful lot of sand in the system". One of the largest basin floor fans identified on the 3D data was from an Upper Cretaceous horizon that is almost 100 km across. The fan is shown in Figure 3, which is an amplitude drape over a spectral decomposition surface. The image shows multiple sediment input canyons, illustrating the fan is a huge amalgamation of clastic supply on the basinal floor.

Moving Up and Downslope

It has been said by TGS before that the deepwater unrestricted basin floor fans are where the best reservoir sands could be found. BP and Kosmos are hunting large turbidite fans in the deepwater off the coast of Mauritania, further north on the West African Margin, and believe these deep fans to hold ten times the prize of their shelf and slope counterparts; perhaps this could be the next target for the Liberian explorer. With recent exploration a little further north in Guinea Conakry opening the margin for deepwater drilling, and water depths of over 2,900m now on the operational agenda, the deepwater turbidite plays are no longer out of technological reach.

It is not just in the deepwater that there is potential for Liberia; the next stage of the TGS and NOCAL exploration effort will be to revaluate and update the interpretation of geophysical data in the basin, including up-dip on to the shelf, which first tempted the industry into the offshore realm. The initial Lyme Bay DRS will be used to extract and extrapolate new thinking, opening new plays throughout the region. An update to this work will be published early in 2018.

References available online. ■

Figure 3: An amplitude drape over a spectral decomposition surface with full stack seismic backdrop.