Quantitative Interpretation Reveals Prospectivity of the Kwanza Shelf, Offshore Angola

PGS in partnership with Agência Nacional de Petróleo, Gás e Biocombustíveis (ANPG) has recently acquired 8,304 sq. km of new multisensor GeoStreamer data over the Kwanza Shelf, 30 km off the central coast of Angola. This new 3D survey provides an unprecedented uplift in seismic imaging over the vintage 2D data. Modern processing workflows have been tailored to the unique imaging challenges of the presence of shallow water and subsurface salt. The new data unveils previously undetected pre-salt basins with many direct hydrocarbon indicators (DHIs) in both the syn-rift and post-rift sections, suggesting the presence of a working petroleum system in this underexplored area.

The Kwanza Shelf represents an enticing area for hydrocarbon exploration, as the Angolan continental margin contains substantial proven reserves and significant remaining untapped potential. This quantitative interpretation project takes advantage of newly available seismic data to examine some of the various post-salt and pre-salt reservoirs. Additionally, an interactive rock physics well atlas was integrated into this study and provides robust insights into the expected seismic response in the area, thus reducing the uncertainties associated with the observed seismic amplitudes.

Figure 1: Final full-stack Kirchhoff Pre-Stack Depth Migrated (KPSDM) 3D line with relative acoustic impedance overlay. The relative acoustic impedance attribute has been generated using PGS’s unique Prospect Scanner workflow. Numerous fluid and lithological anomalies are highlighted across pre-salt and post-salt targets. The complex network of turbidite channel and fan systems in the post-rift section are now seen to confidently imaged in 3D across the area. Close imaging of the pre-salt interval enables a detailed analysis of the stratigraphy and robust reservoir characterization of these deposits.
The Kwanza Shelf is situated within the Kwanza Basin, located in the southern part of the West African Agua sub-basin. The Agua region is known for its rich hydrocarbon potential. The shelfal area shown here in a 3D section display combined with Catumbela horizon sweetness and relative IP geobody extraction has confirmed the presence of hydrocarbons. Integration of well and pre-stack seismic inversion results allowed the generation of a well-calibrated 3D model that accurately represents the basin's tectonic history.

Figure 2: The Catumbela Formation (Albian), mainly composed of oolitic shoals, exhibits porosities in excess of 20% in the region, and well data restricted evaporitic facies to open marine deposition.

The post-rift is characterized by a shift from restricted evaporitic facies to open marine deposition and contains four main reservoir units: Albian Fenda Shell formation sandstones, Late Cretaceous lake facies alluvial sandstones and turbidites of Palaeocene-Eocene Lancundo Formation sandstones; and Oligocene/Miocene Quifangondo Formation sandstones.

Exploration History: The Overlooked Kwanza Shelf

A total of 43 wells drilled on the Kwanza Shelf; 31 wells were drilled prior to 1991. Exploration moved to deeper water targets during the early 2000s following the rise in analogues to the super-giant Lula oil field discovered in the Santos Basin, Brazil.

On the shelf, only two exploration wells have been drilled using early 1990s' 3D seismic, while the remainder used 2D data from the 1980s. Despite the limitations associated with mapping features using 2D seismic, drilling for oil has successfully intersected high porosity and permeability sands.

Enhanced 3D Broadband Imaging to Reveal Potential

Improved imaging of the Aptian Loeme Formation is vital in unlocking the future prospectivity of the undersampled Kwanza Shelf area, and a detailed velocity model addressing the range of 26–30%, with permeabilities above 400 mD. Porosity in these sandstone deposits is estimated to be in the range of 26–30%, with permeabilities above 400 mD. Two main structural configurations can provide a pathway for hydrocarbons generated from eyes off source rock to migrate into these deeper volumes. The second occurs in areas where complete salt welds result in mini-basin salt walls. Such areas are found in areas where faults caused by halokinesis extend through the post-rift section.

Improved 3D Broadband Quantitative Interpretation to Highlight Prospective Areas

Quantitative interpretation analysis has been performed over the entire region (post-salt and pre-salt) using conditioned partial angle stacks. For the seismic conditioning, a Reservoir Oriented Processing (ROP) workflow was performed using four angle stacks. The processing sequence included denoise, spectral conditioning, and time migration correction. Time-migrated, intercept and gradient attributes were estimated and integrated through the Prospect Scainer workflow to derive elastic attributes such as relative Acoustic Anisotropy and relative VP/Vs. Anisotropy was calculated using a robust well data consistency ensuring a correspondence between well and seismic data. Seismic responses that could be related to halokinesis in-situ well responses, were further analysed using visualising the availability rock physics attributes (RPA rock 1995), via petrofacies in real time of porosity, fluid and saturation over such seismic intervals.

accumulations proved that both pre-salt and post-salt plays extend from the onshore to offshore, further helping to de-risk the prospectivity of the Kwanza Shelf. The mapped model (…) led to the discovery of the Bombeck and proved the pre-salt play. Aptian post-salt carbonate reservoirs formed in a basement environment range in sandstone facies and quality to values with primary porosities up to 15% and secondary post-salt porosity enhancement due to halokinesis.

The post-salt Albian play, proven in the Cegonha and Mubafo fields, highlights a working petroleum system with reservoirs in post-salt deltaic sandstones and shallow turbidites. The pre-salt formations show excellent reservoir potential with primary porosity values in the 20–25% range, as evidenced by well data drilled in the vicinity. A total porosity range of 15–25% combined with well data in the pre-salt area, could generate confidence max high-porosity carbonate reservoirs over the Kwanza Shelf. Multiplehydrocarbon indicators (DHIs) can be identified within channelized sandstone deposits in the post-salt section. Tertiary turbidite facies on the Kwanza Shelf are analogous to the prolific gas and oil bearing turbidites found to the north in the Lower Congo Basin. Potential in these sandstone deposits is estimated to be in the range of 26–40%, with permeabilities above 1000 md. Two main structural configurations can provide a pathway for hydrocarbons generated from eyes off source rock to migrate into these deeper volumes. The second occurs in areas where complete salt welds result in mini-basin salt walls. Such areas are found in areas where faults cause by halokinesis extend through the post-salt section and terminate at the top of the pre-salt (Figure 2).

Opportunities Revealed by GeoStreamer Dataset for Offshore Angola 2021 Licence Round

The new GeoStreamer seismic dataset over the offshore Kwanza Shelf provides exceptional 2D imaging of both pre- and post-salt sequences in the area. The new seismic data, in conjunction with an interactive rock physics atlas, allows for a fully integrated quantiative seismic data interpretation workflow which reveals opportunities across the undersampled Kwanza Shelf area. The insights gained from this study demonstrate how important new data can be in unlocking the prospectivity of the area for the upcoming Angola 2021 licence round.

The Kwanza Shelf is located in the southern part of the West African Agua sub-basin. The Agua region is known for its rich hydrocarbon potential. The shelfal area shown here in a 3D section display combined with Catumbela horizon sweetness and relative IP geobody extraction has confirmed the presence of hydrocarbons. Integration of well and pre-stack seismic inversion results allowed the generation of a well-calibrated 3D model that accurately represents the basin's tectonic history.

Figure 2: The Catumbela Formation (Albian), mainly composed of oolitic shoals, exhibits porosities in excess of 20% in the region, and well data restricted evaporitic facies to open marine deposition.

The post-rift is characterized by a shift from restricted evaporitic facies to open marine deposition and contains four main reservoir units: Albian Fenda Shell formation sandstones, Late Cretaceous lake facies alluvial sandstones and turbidites of Palaeocene-Eocene Lancundo Formation sandstones; and Oligocene/Miocene Quifangondo Formation sandstones.

Exploration History: The Overlooked Kwanza Shelf

A total of 43 wells drilled on the Kwanza Shelf; 31 wells were drilled prior to 1991. Exploration moved to deeper water targets during the early 2000s following the rise in analogues to the super-giant Lula oil field discovered in the Santos Basin, Brazil.

On the shelf, only two exploration wells have been drilled using early 1990s’ 3D seismic, while the remainder used 2D data from the 1980s. Despite the limitations associated with mapping features using 2D seismic, drilling for oil has successfully intersected high porosity and permeability sands.

Enhanced 3D Broadband Imaging to Reveal Potential

Improved imaging of the Aptian Loeme Formation is vital in unlocking the future prospectivity of the undersampled Kwanza Shelf area, and a detailed velocity model addressing the range of 26–30%, with permeabilities above 400 mD. Porosity in these sandstone deposits is estimated to be in the range of 26–30%, with permeabilities above 400 mD. Two main structural configurations can provide a pathway for hydrocarbons generated from eyes off source rock to migrate into these deeper volumes. The second occurs in areas where complete salt welds result in mini-basin salt walls. Such areas are found in areas where faults caused by halokinesis extend through the post-rift section.

Improved 3D Broadband Quantitative Interpretation to Highlight Prospective Areas

Quantitative interpretation analysis has been performed over the entire region (post-salt and pre-salt) using conditioned partial angle stacks. For the seismic conditioning, a Reservoir Oriented Processing (ROP) workflow was performed using four angle stacks. The processing sequence included denoise, spectral conditioning, and time migration correction. Time-migrated, intercept and gradient attributes were estimated and integrated through the Prospect Scainer workflow to derive elastic attributes such as relative Acoustic Anisotropy and relative VP/Vs. Anisotropy was calculated using a robust well data consistency ensuring a correspondence between well and seismic data. Seismic responses that could be related to halokinesis in-situ well responses, were further analysed using visualising the availability rock physics attributes (RPA rock 1995), via petrofacies in real time of porosity, fluid and saturation over such seismic intervals.

accumulations proved that both pre-salt and post-salt plays extend from the onshore to offshore, further helping to de-risk the prospectivity of the Kwanza Shelf. The mapped model (…) led to the discovery of the Bombeck and proved the pre-salt play. Aptian post-salt carbonate reservoirs formed in a basement environment range in sandstone facies and quality to values with primary porosities up to 15% and secondary post-salt porosity enhancement due to halokinesis.

The post-salt Albian play, proven in the Cegonha and Mubafo fields, highlights a working petroleum system with reservoirs in post-salt deltaic sandstones and shallow turbidites. The pre-salt formations show excellent reservoir potential with primary porosity values in the 20–25% range, as evidenced by well data drilled in the vicinity. A total porosity range of 15–25% combined with well data in the pre-salt area, could generate confidence max high-porosity carbonate reservoirs over the Kwanza Shelf. Multiple hydrocarbon indicators (DHIs) can be identified within channelized sandstone deposits in the post-salt section. Tertiary turbidite facies on the Kwanza Shelf are analogous to the prolific gas and oil bearing turbidites found to the north in the Lower Congo Basin. Potential in these sandstone deposits is estimated to be in the range of 26–40%, with permeabilities above 1000 md. Two main structural configurations can provide a pathway for hydrocarbons generated from eyes off source rock to migrate into these deeper volumes. The second occurs in areas where complete salt welds result in mini-basin salt walls. Such areas are found in areas where faults cause by halokinesis extend through the post-salt section and terminate at the top of the pre-salt (Figure 2).

Opportunities Revealed by GeoStreamer Dataset for Offshore Angola 2021 Licence Round

The new GeoStreamer seismic dataset over the offshore Kwanza Shelf provides exceptional 2D imaging of both pre- and post-salt sequences in the area. The new seismic data, in conjunction with an interactive rock physics atlas, allows for a fully integrated quantiative seismic data interpretation workflow which reveals opportunities across the undersampled Kwanza Shelf area. The insights gained from this study demonstrate how important new data can be in unlocking the prospectivity of the area for the upcoming Angola 2021 licence round.