



Maximising Angola's Potential: Prospectivity of the Kwanza Basin

A review from the onshore to deep-water

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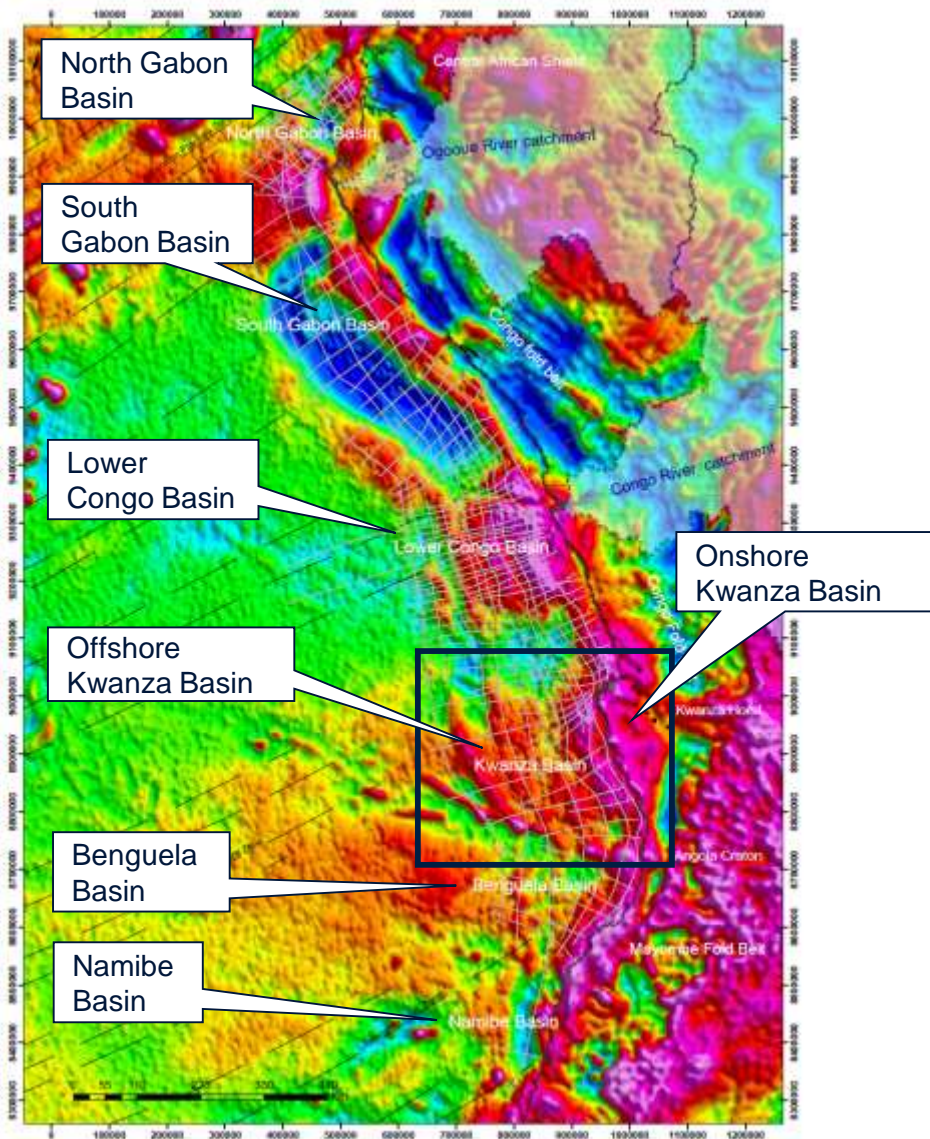
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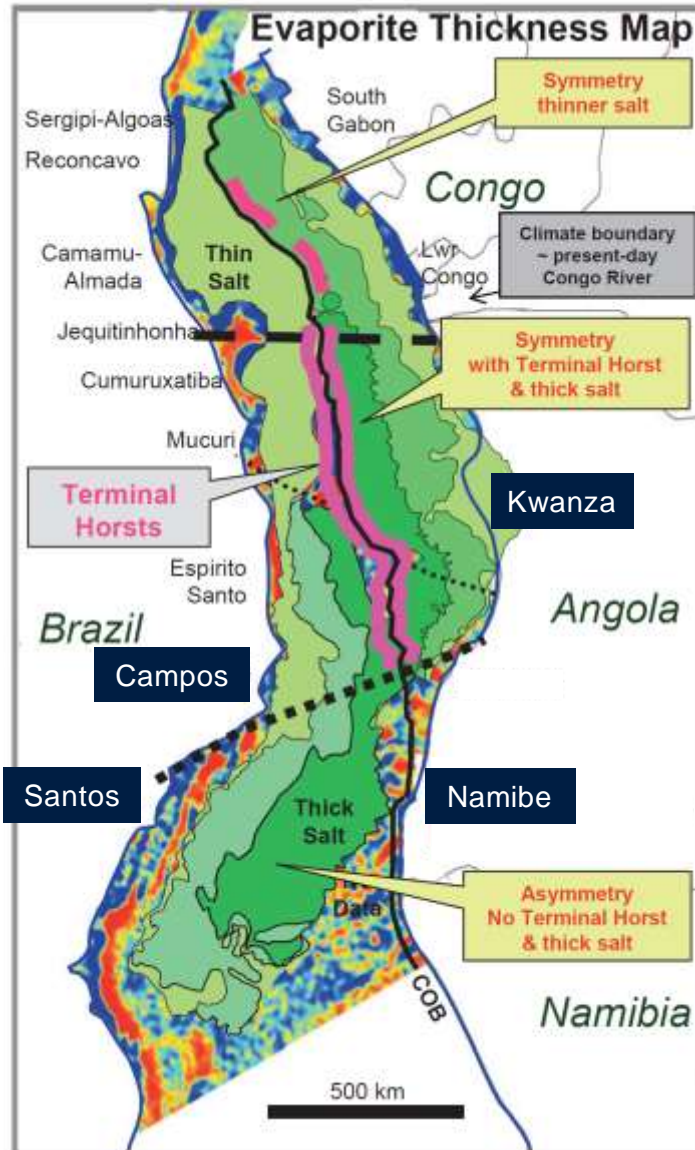
West African Margin

- The Kwanza Basin is located on the West African continental margin of the Central South Atlantic.
- The West African margin contains a series of basins segmented by fracture zones and volcanic highs, developed as a result of the break-up of Gondwanaland during the Early Cretaceous.
- The West African basins display a range of crustal, stratigraphic and structural styles which have strongly influenced play development and hydrocarbon potential.



Sandwell Free Air Gravity – purple+ve, blue -ve

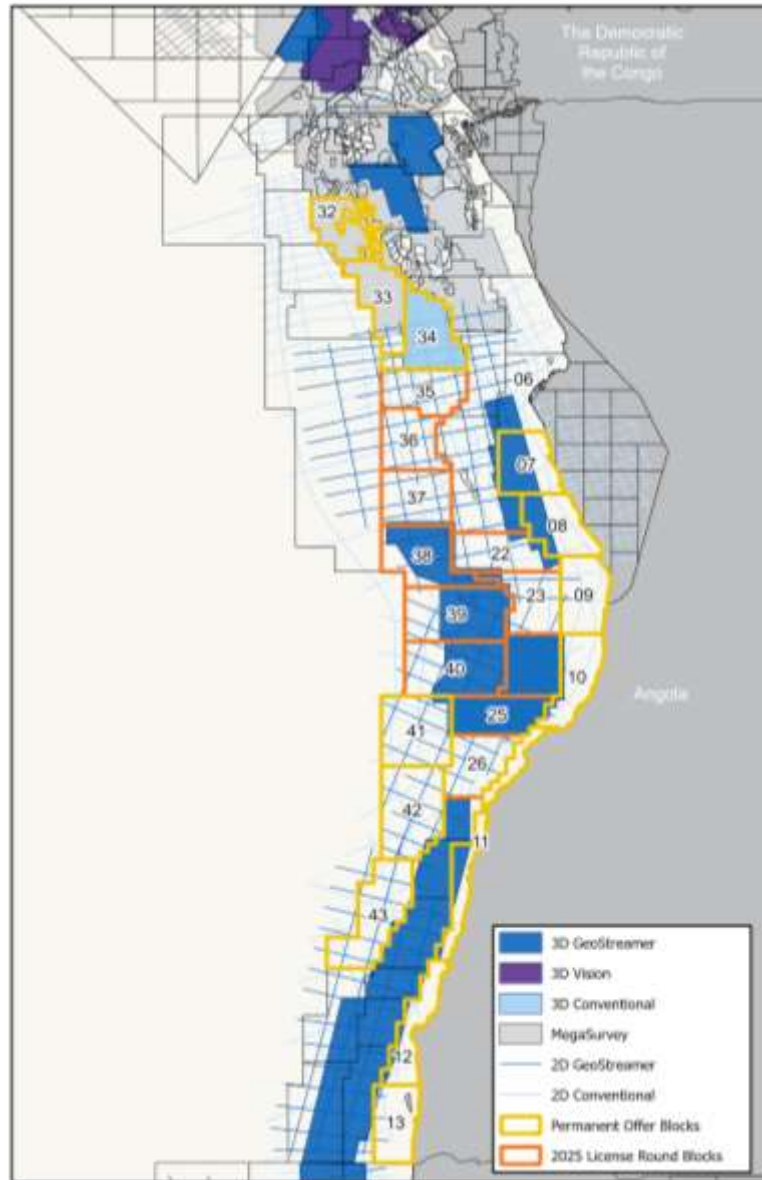
Geological Setting



Modified from Lentini et al 2010

- The Kwanza Basin is part of the South Atlantic salt province, stretching from the Sergipe-Alagoas - South Gabon conjugate pair, to the Santos in the south.
- Symmetrical rifting in the north, asymmetric in the south.
- Salt is thin in the onshore Kwanza and shelfal areas, thickening towards the outboard.

Seismic Data Coverage



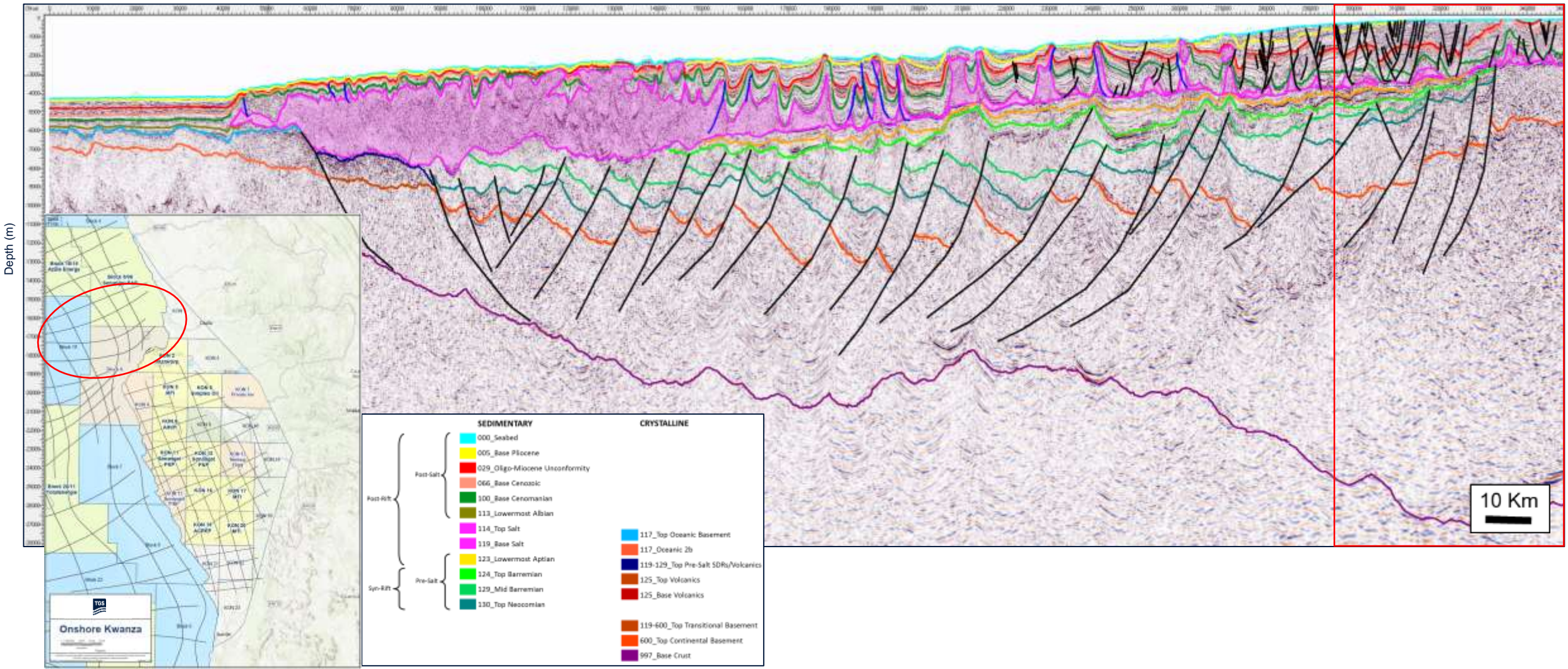
- Kwanza Basin Seismic Data

- ANG Kwanza MC3D GeoStreamer (2012 acquisition) - 26,300 sq. km
- Kwanza Shelf MC3D GeoStreamer (2019 acquisition) - 8,304 sq. km
- Angola Offshore MC2D GeoStreamer (2011 acquisition) - 12,465 line km
- SPAN MC2D (2004 & 2007 acquisition, reprocessed in 2018) - 17,705 line km
- Onshore MC2D (2010-12 acquisition) - 2589 line km
 - Currently undergoing reprocessing with deliverables available soon

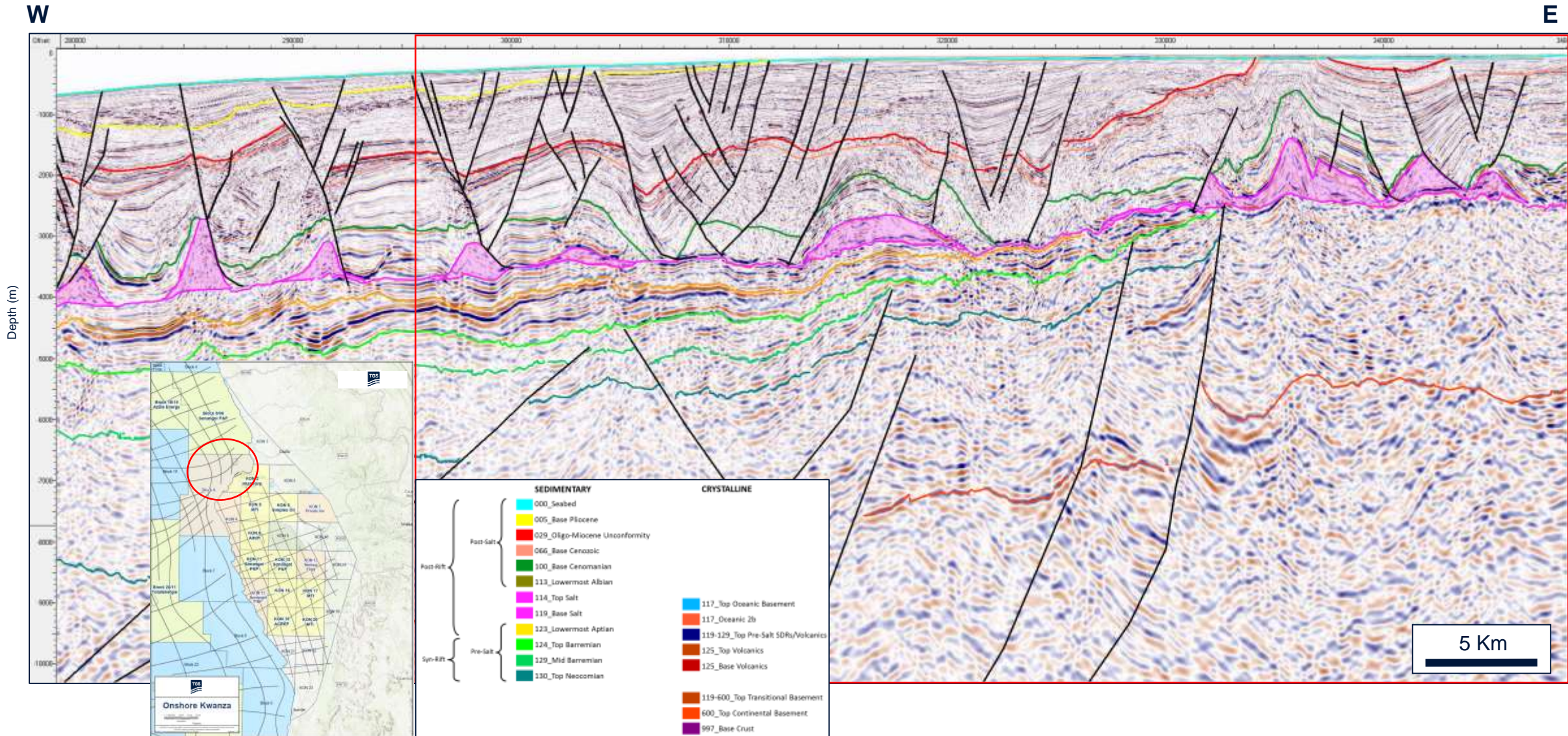
Regional Section - Offshore Kwanza Basin

W

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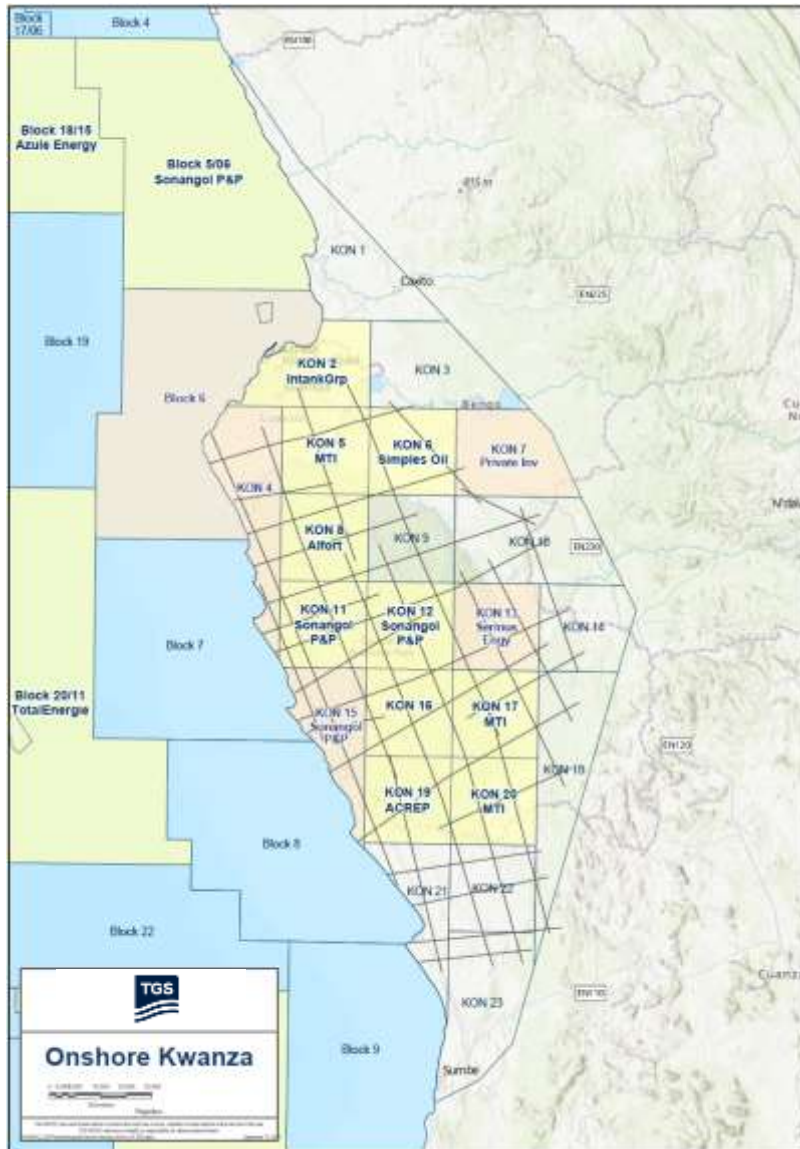
Offshore (Shelfal) Kwanza Basin





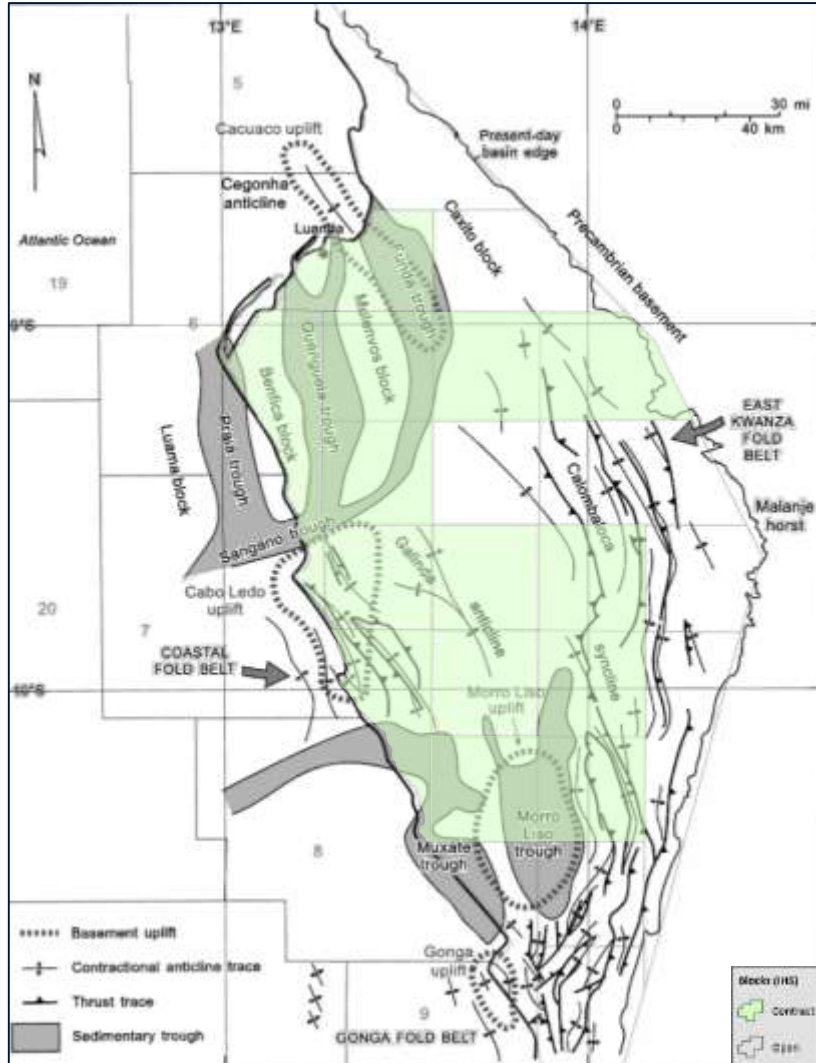
Onshore Kwanza

Onshore Kwanza Basin



- The Onshore (Inner) Kwanza Basin covers an area of approximately 25,000 sq. km.
- 182 exploration and appraisal wells have been drilled, resulting in the discovery of 11 oil fields and 2 small gas fields.
- A regional 2D seismic dataset was acquired from 2010 to 2012 on behalf of Sonangol over the entire Onshore Kwanza Basin.
- Nearly 2600 line km provides enhanced imaging of pre- and post-salt stratigraphy. PSTM and PSDM data are available.
- Blocks are licensed by multiple operators.

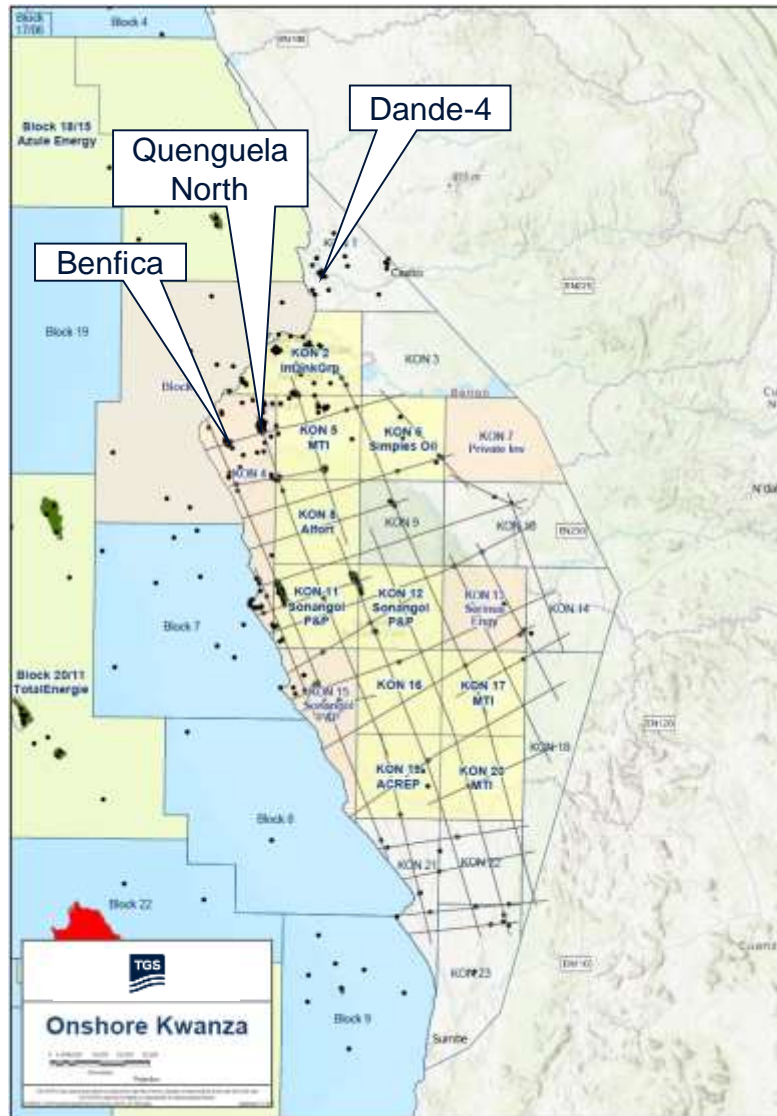
Onshore Basin Structure



The Kwanza Basin contains a host of major structural features including:

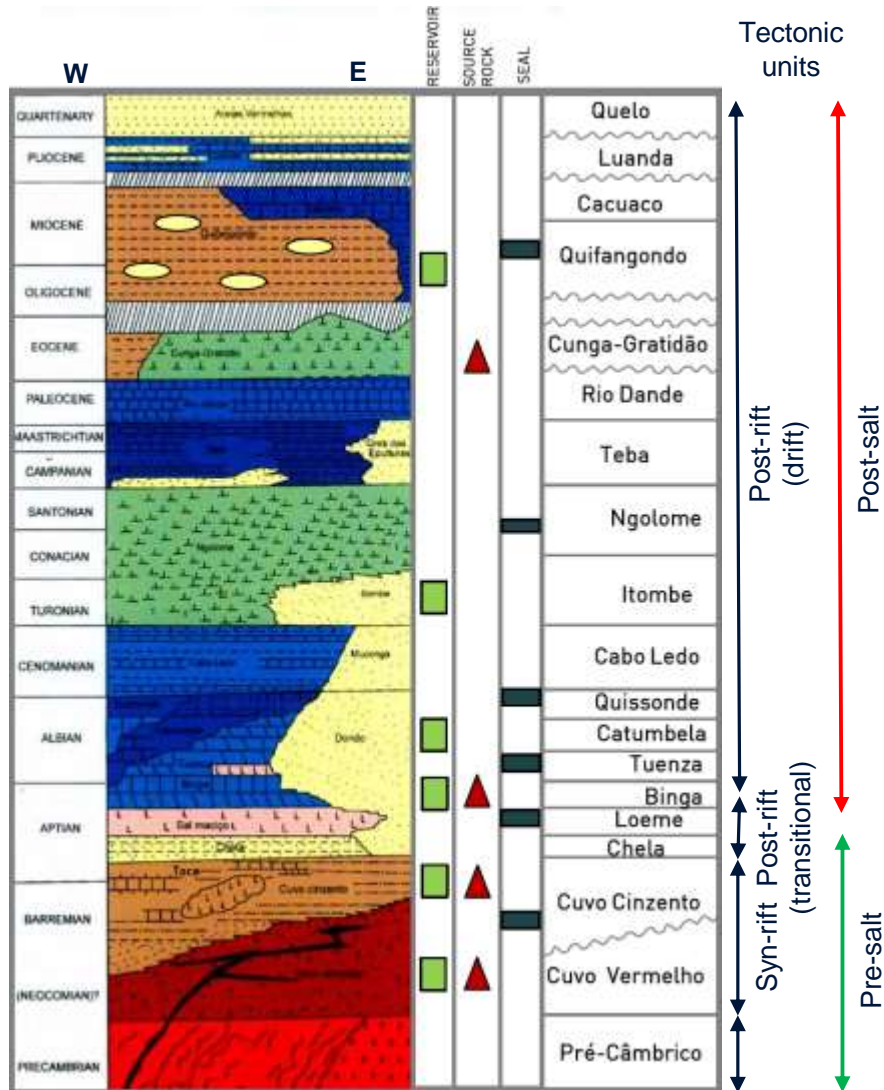
- Tertiary sedimentary troughs created by salt withdrawal
- Cretaceous rafts between these Tertiary troughs
- Anticlines, synclines and basement uplifts
- Thrust faults of the East Kwanza Fold Belt onshore, Coastal Fold Belt and Gongas Fold Belt offshore

Exploration History



- Oil seeps and asphalt deposits were discovered in the late 1700s at the eastern edge of the basin in Libongos, 60km north of Luanda.
- Exploration drilling began in 1915 and a non-commercial oil discovery was made in 1916 at Dande-4.
- The first commercial oil discovery in the basin was made in 1955 at Benfica.
- In 1967 the largest field in the onshore Kwanza Basin, Quenguela North, was discovered.
- Total in place discovered reserves for the basin are reported at 326.8 MMBoe.
- During the late 1980s to late 1990s, the onshore Kwanza fields were shut-in and all were abandoned by 2000.
- A hiatus in E&A drilling occurred from 1983 until 2023 until the Tobias-13 and -14 appraisal wells were drilled.
- Of 182 E&A wells drilled in the basin, only 28 of them penetrated the pre-salt and most reached TD after <100m of that section.
- Drilling resumed in the basin in 2023 with the Tobias-13 appraisal well (KON 11).

Petroleum Systems & Plays



(Sonangol, 2014)

Three main plays are present in the Onshore Kwanza Basin:

Pre-salt

Source: Syn-rift Cuvo Fm (Bucomazi Fm equivalent)

Reservoir: Syn-rift Cuvo Fm & sag-phase Chela Fm clastics, Toca Fm equivalent carbonates

Seal: Aptian Salt, Intraformational shales in Cuvo Fm

Albian

Source: Syn-rift Cuvo Fm (Bucomazi Fm equivalent), Bituminous limestones in Albian Binga Fm

Reservoir: Aptian to Cenomanian carbonates (Binga Fm (oolitic carbonate), Tuenza Fm, Catumbela Fm, Cabo Ledo Fm)

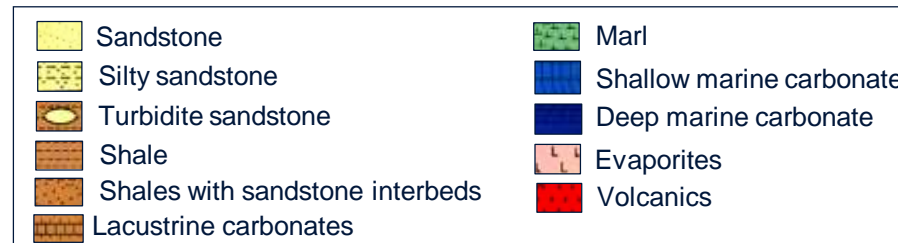
Seal: Albian Tuenza Fm evaporites, Late Albian Quissonde Fm, Upper Cretaceous Ngolome Fm shales

Upper Cretaceous to Oligo-Miocene

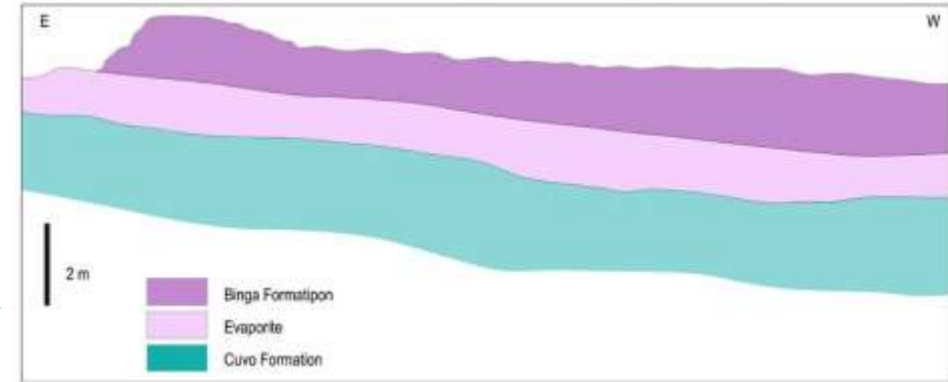
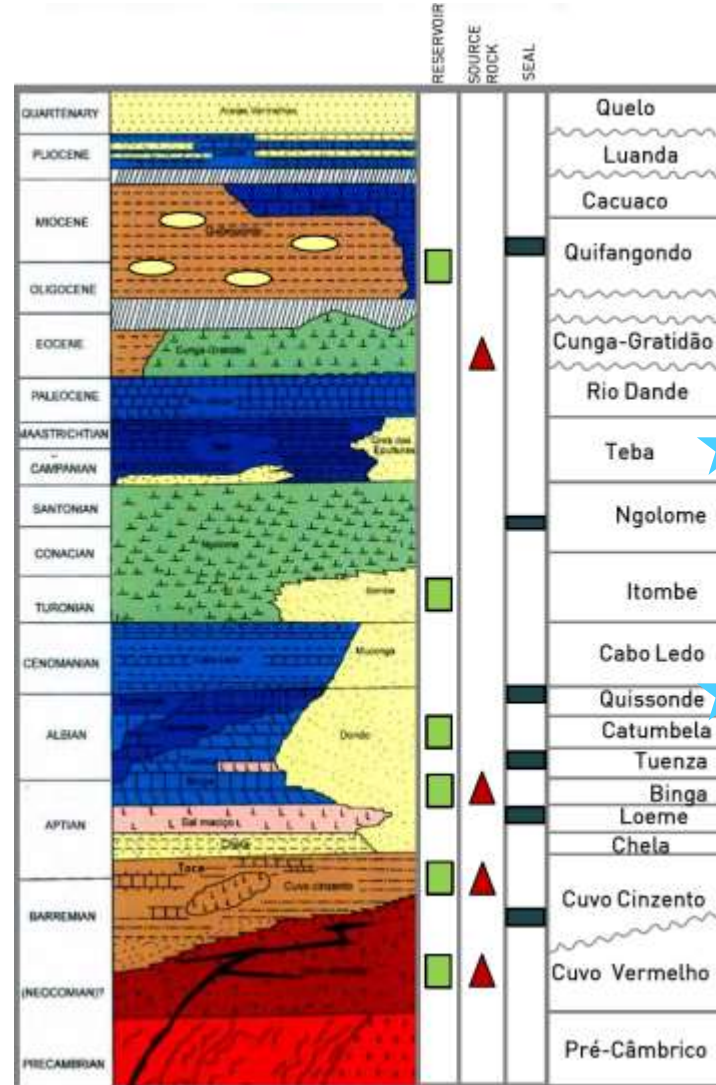
Source: Syn-rift Cuvo Fm (Bucomazi Fm equivalent), Eocene Cunga-Gratidão Fm shales

Reservoir: Cenomanian Itombe Fm and Oligo-Miocene Quifangondo Fm deepwater clastics

Seal: Upper Cretaceous Ngolome Fm shales and intraformational Oligo-Miocene Quifangondo Fm shales

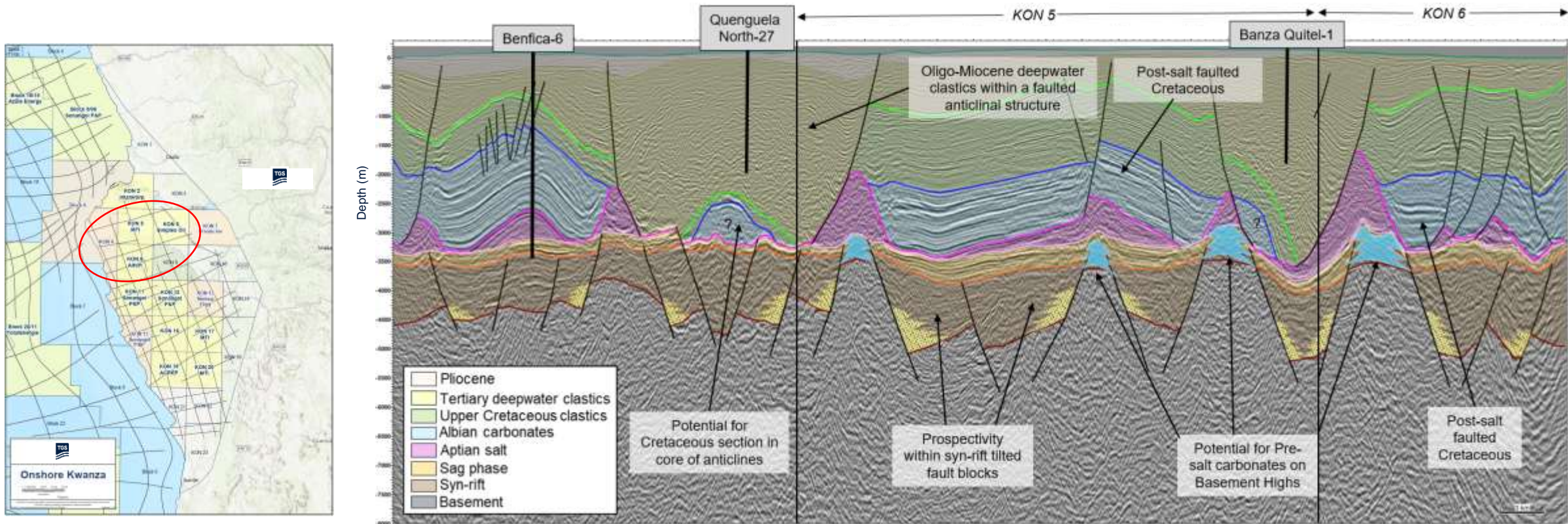


Onshore Fieldwork

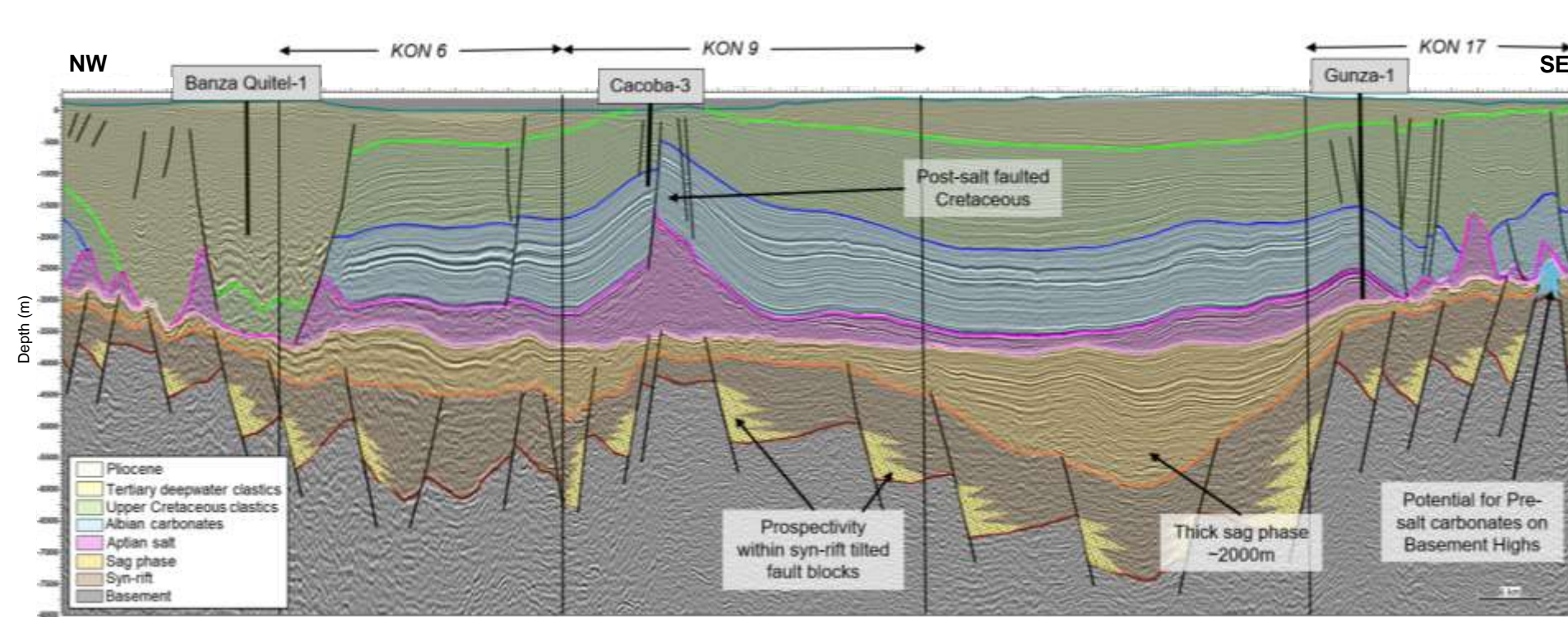


★ Source rocks identified in outcrop and analysed

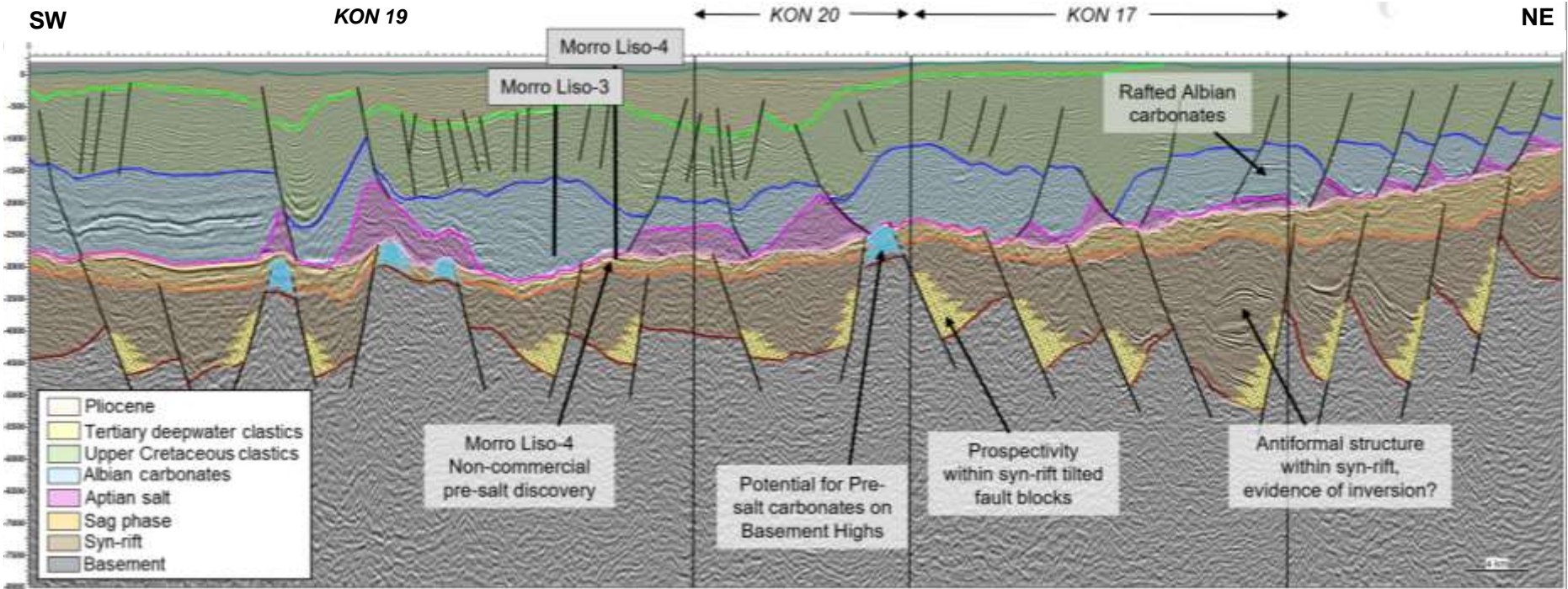
Cross-section of Onshore (Inner) Kwanza Basin



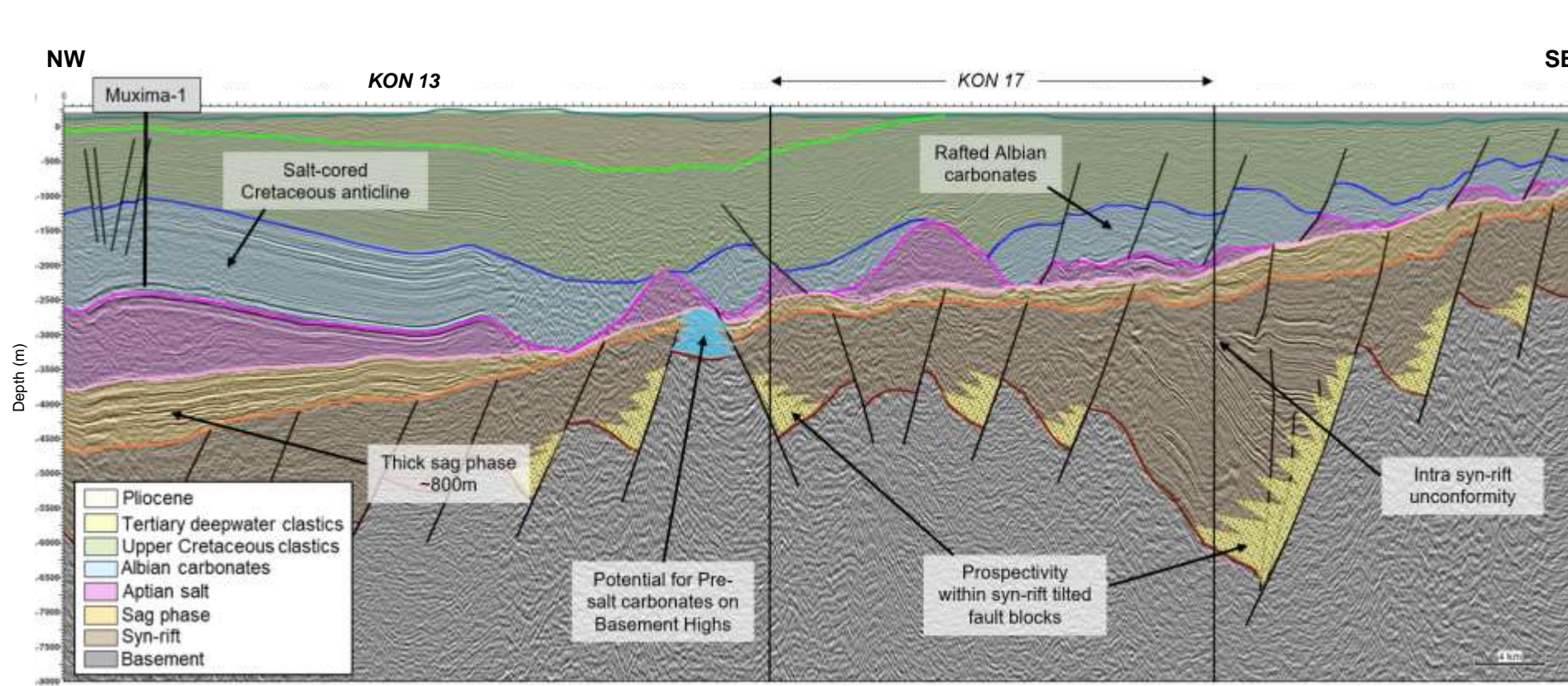
Example Strike Line - Basin Centre



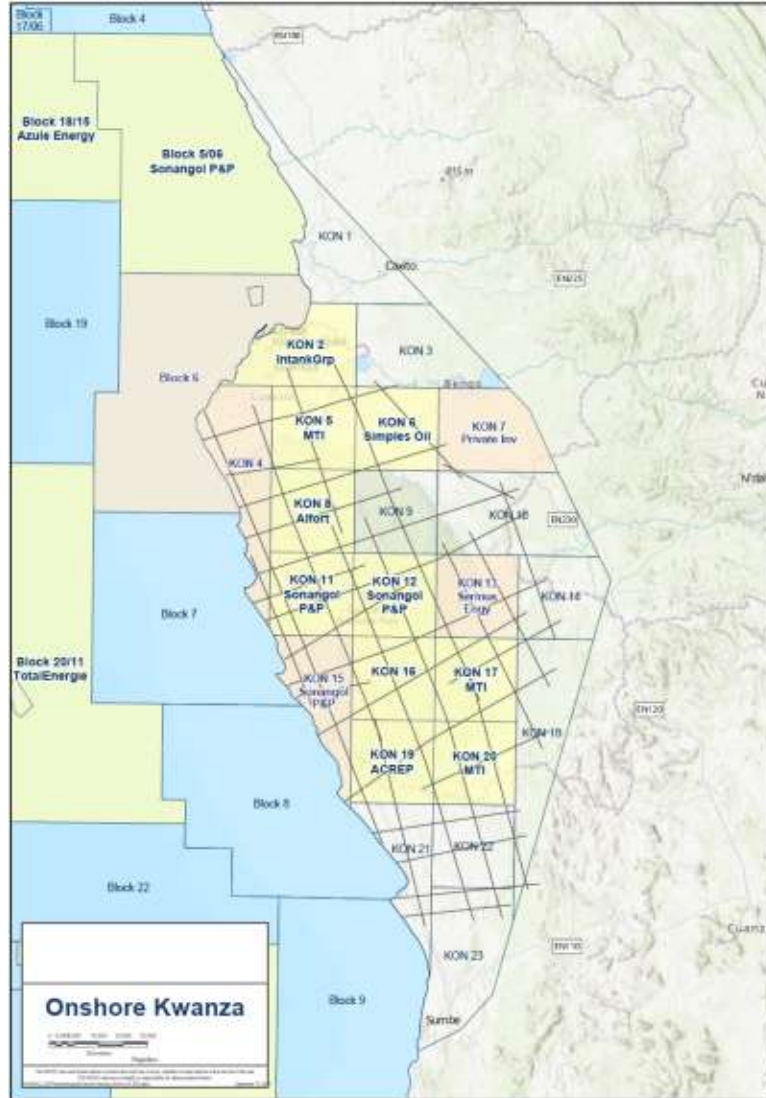
Example Dip Line - South



Example Strike Line - South-East

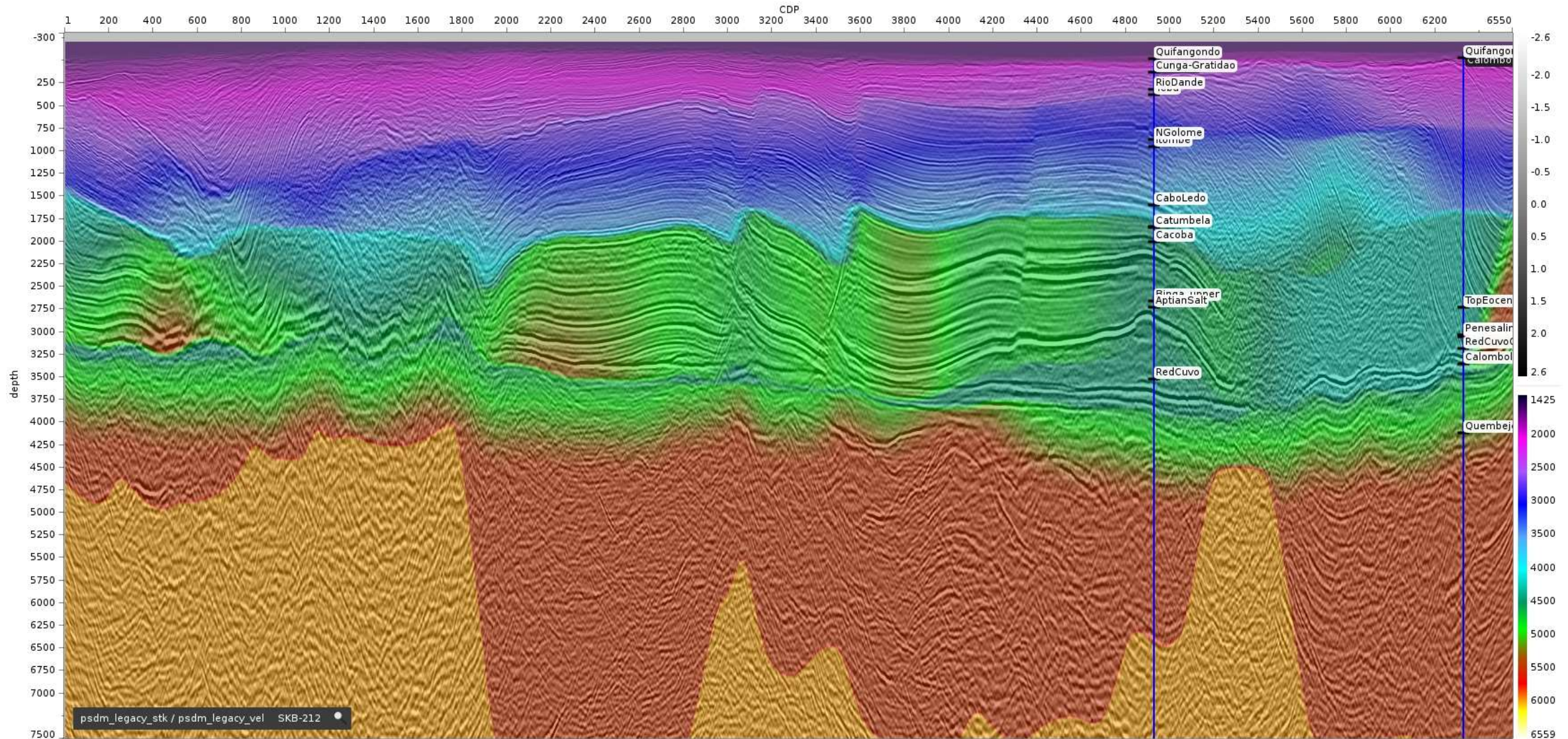


Onshore 2D Reprocessing

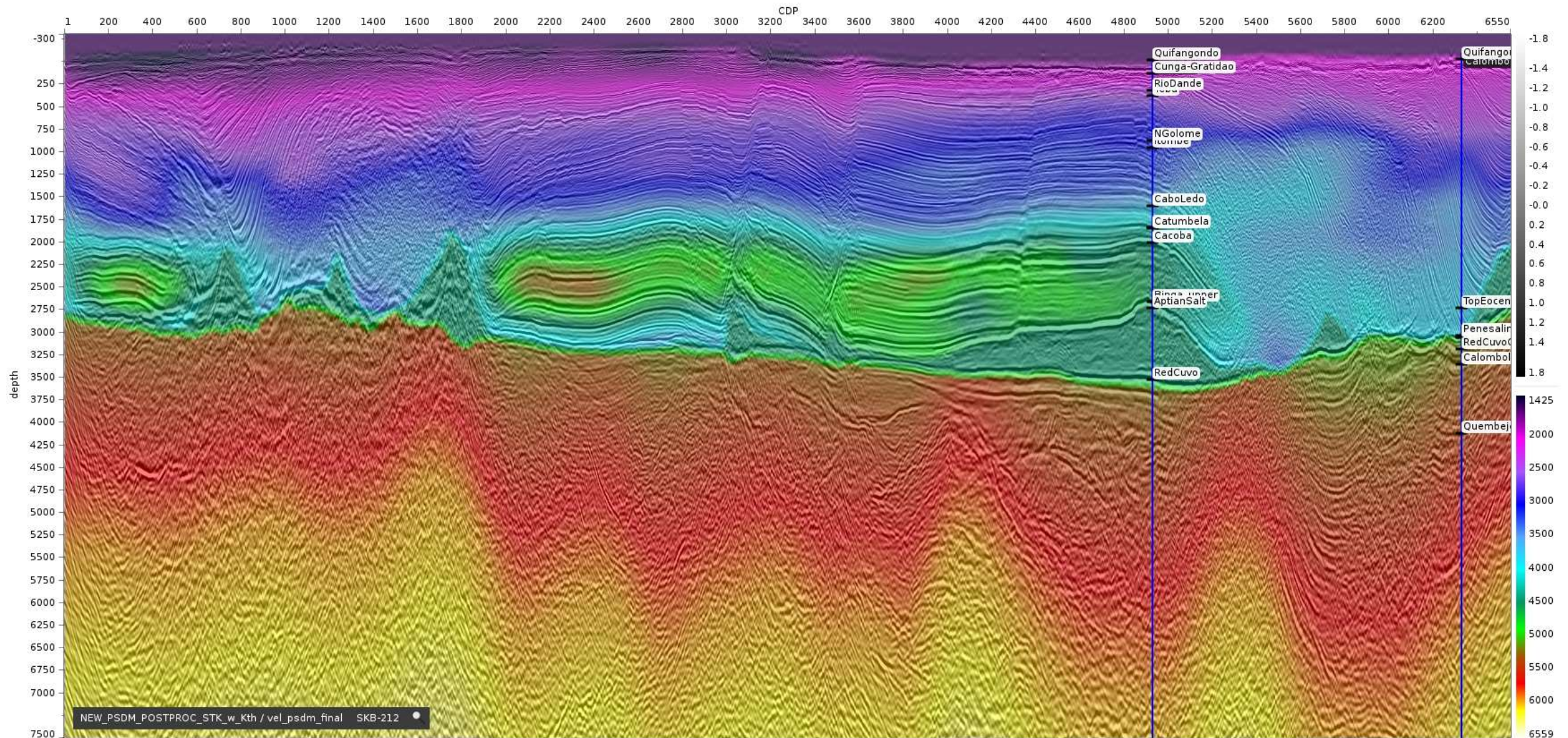


- Complete 2589 line km, 2010-12 acquisition is undergoing reprocessing
- Modern PSDM workflow
- Enhanced imaging, particularly of the pre-salt
- Final deliverables will be available 4Q 2024

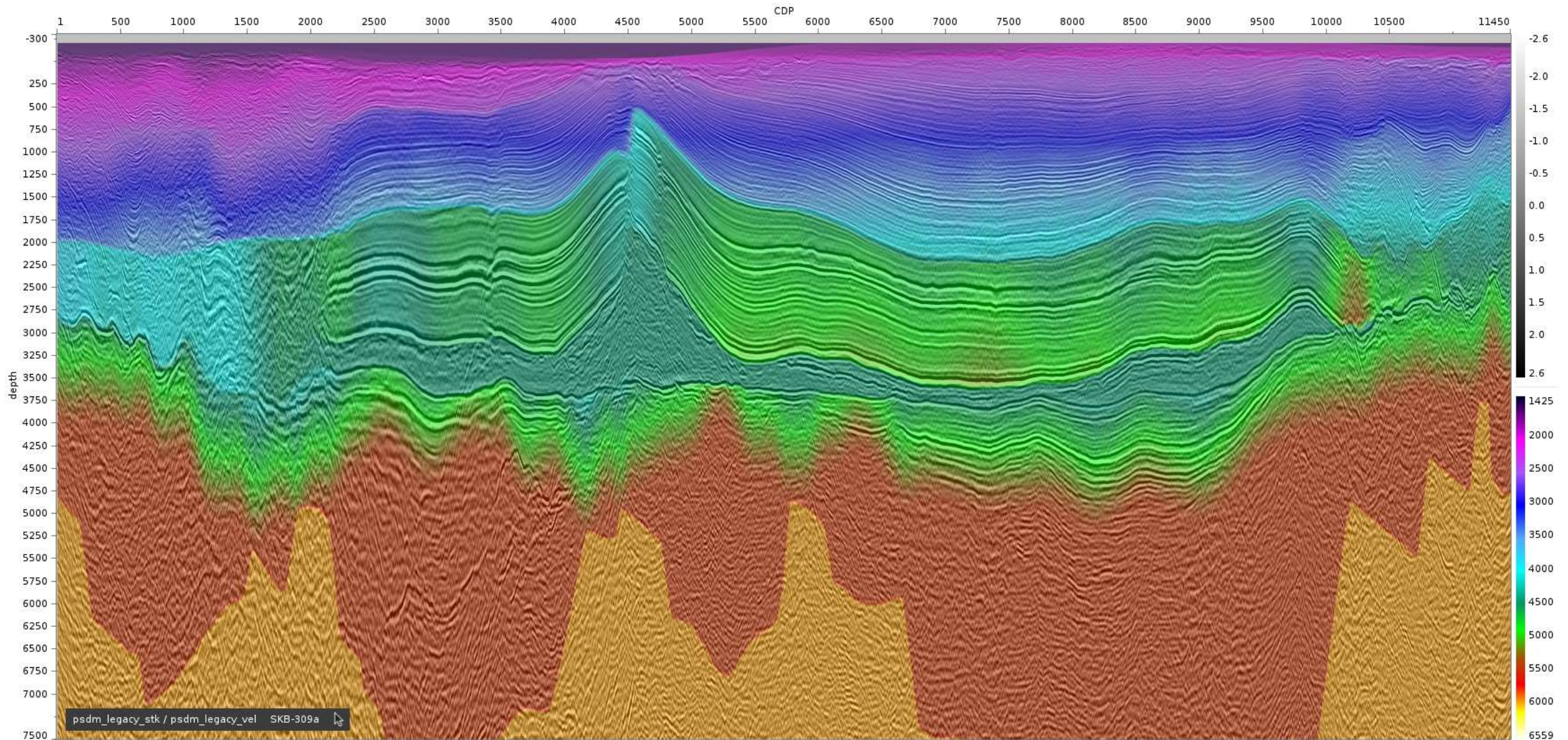
Onshore 2D Reprocessing Legacy PSDM Stack and Velocity



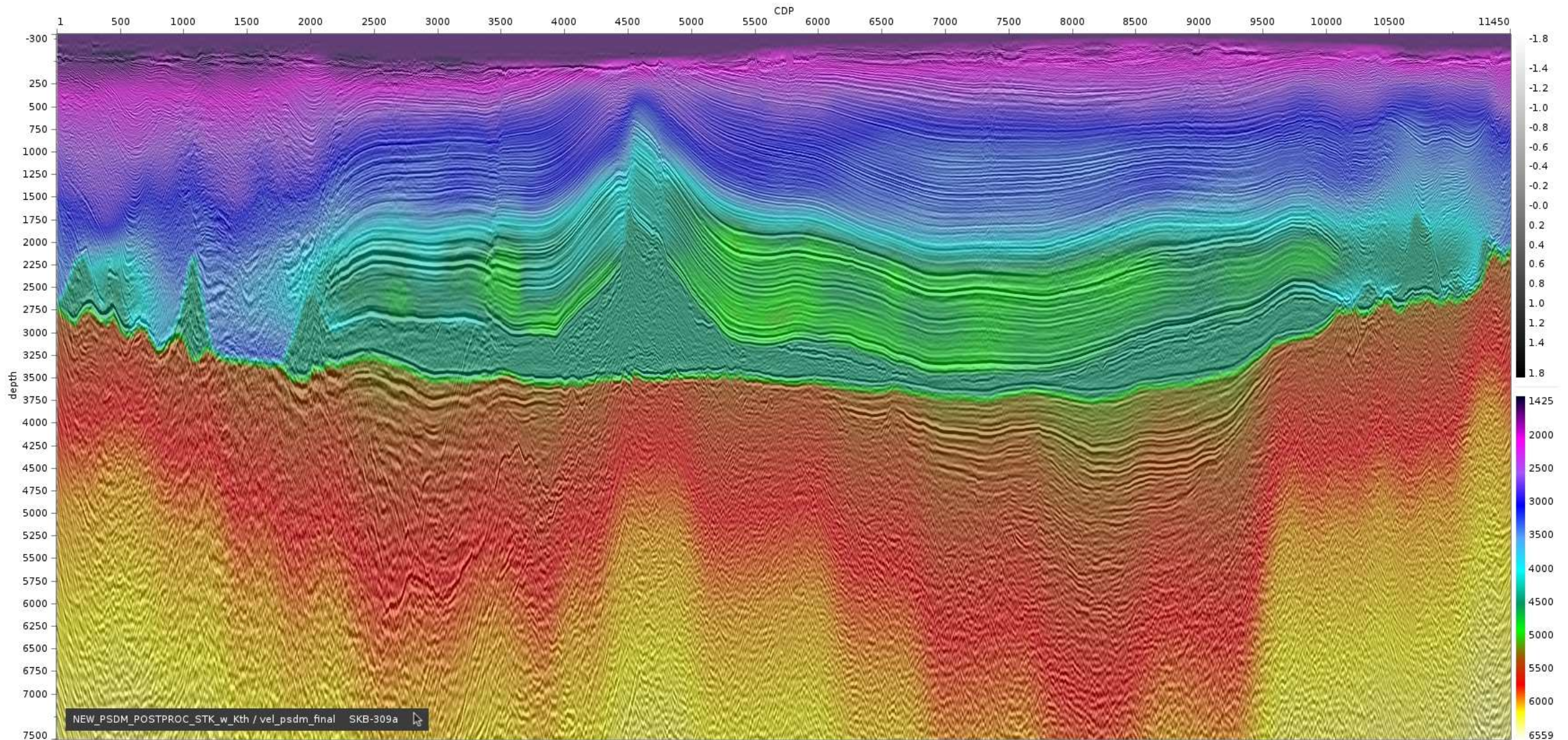
Onshore 2D Reprocessing Repro PSDM stack and velocity



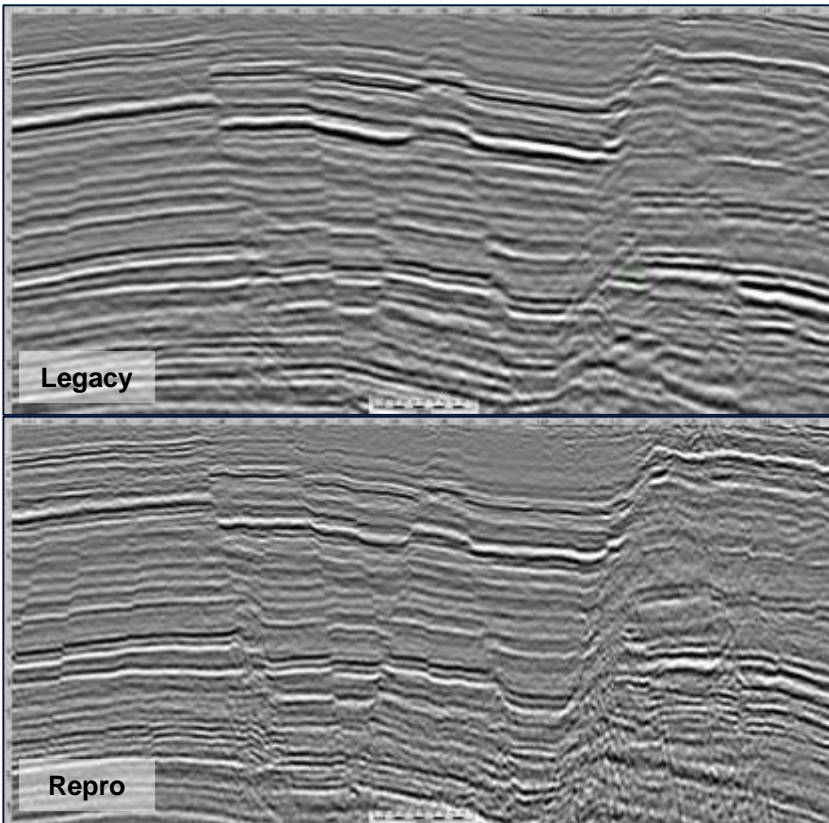
Onshore 2D Reprocessing Legacy PSDM stack and velocity



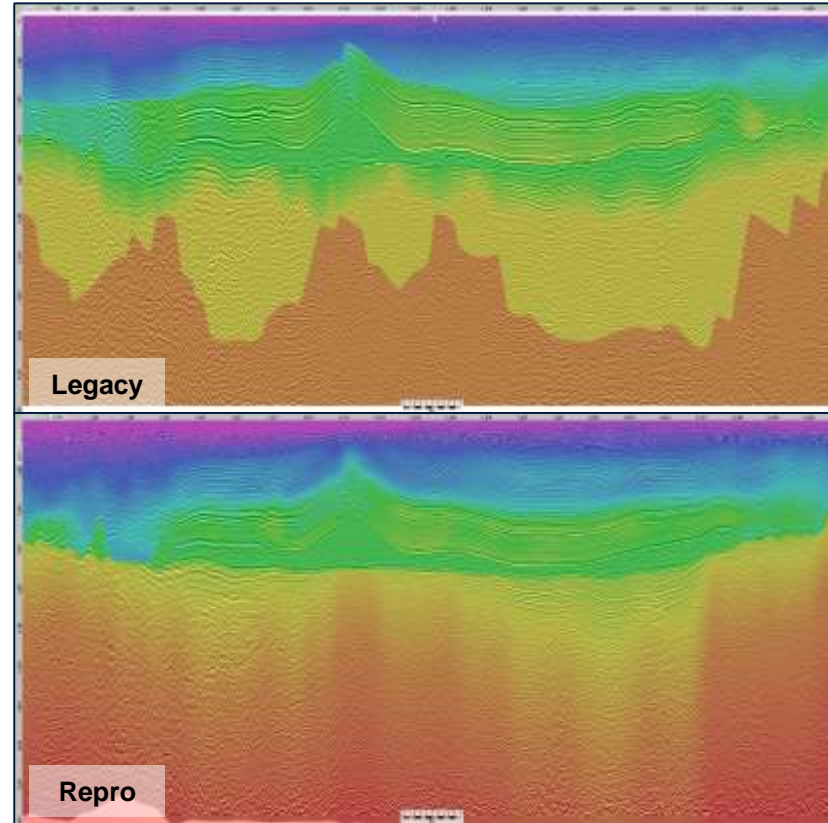
Onshore 2D Reprocessing Repro PSDM stack and velocity



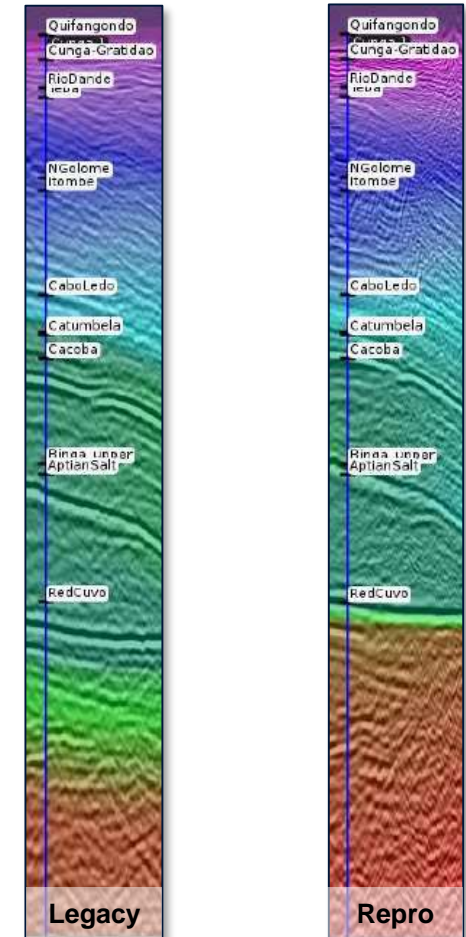
Summary of Onshore 2D Reprocessing Test



- Improved frequency content
- Improved imaging of faulting and stratigraphy



- Improved velocity model
- Conformable with the geological structure
- Survey lines are tied

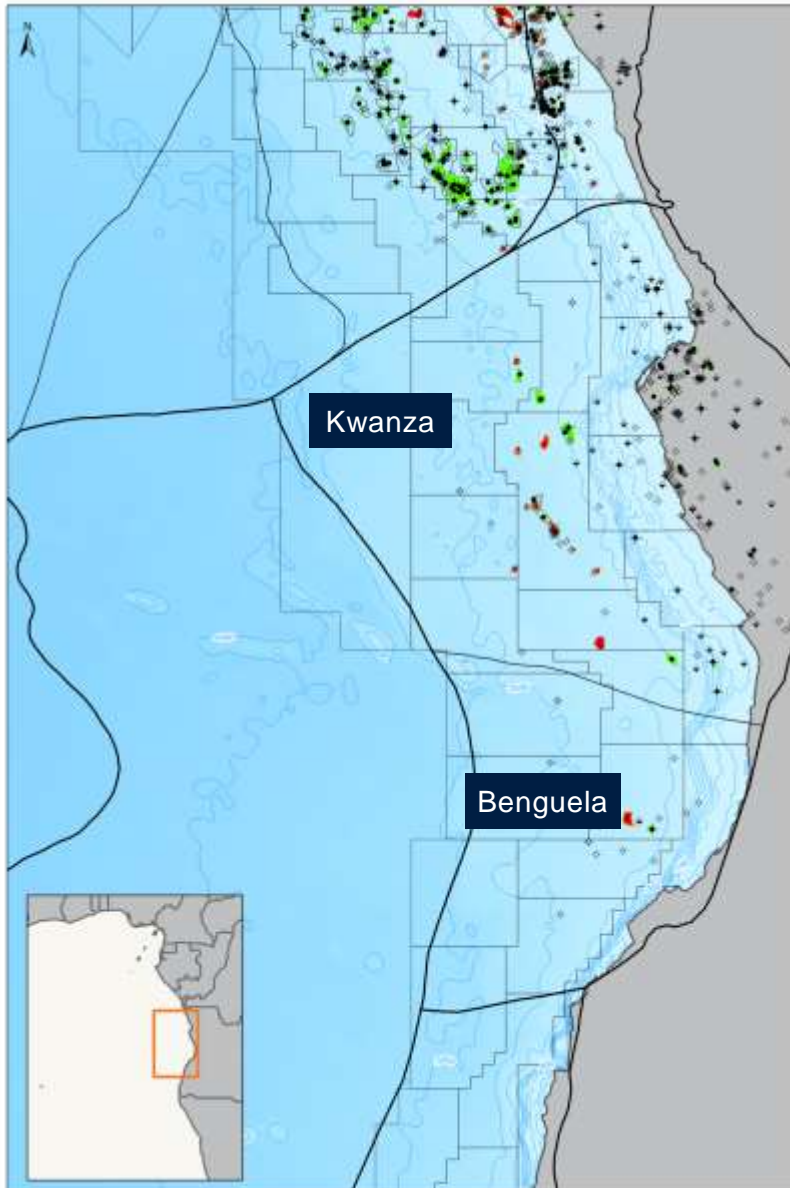


- Repro seismic data is tied to the available well data



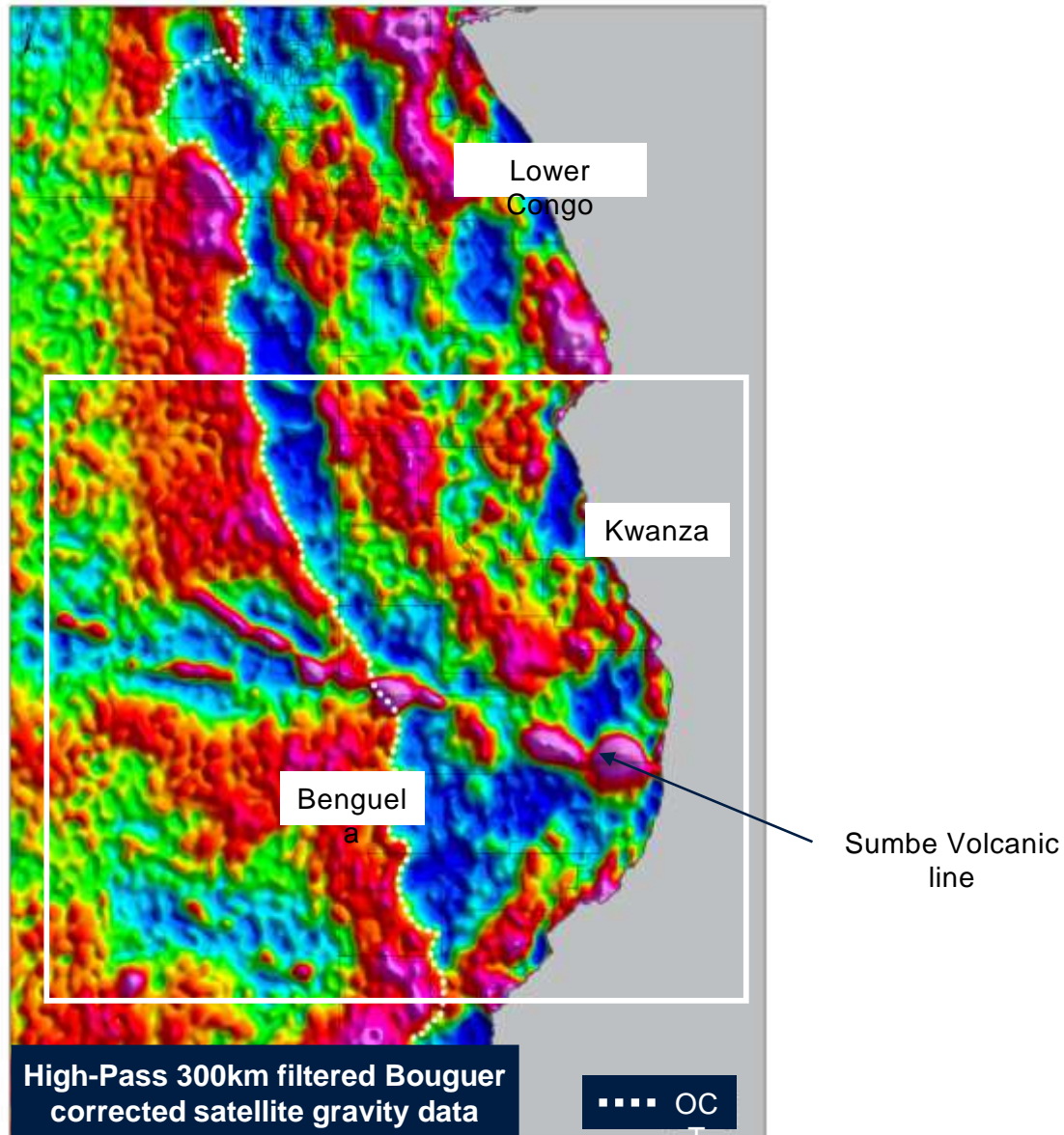
Offshore Kwanza-Benguela

Offshore Kwanza Basin



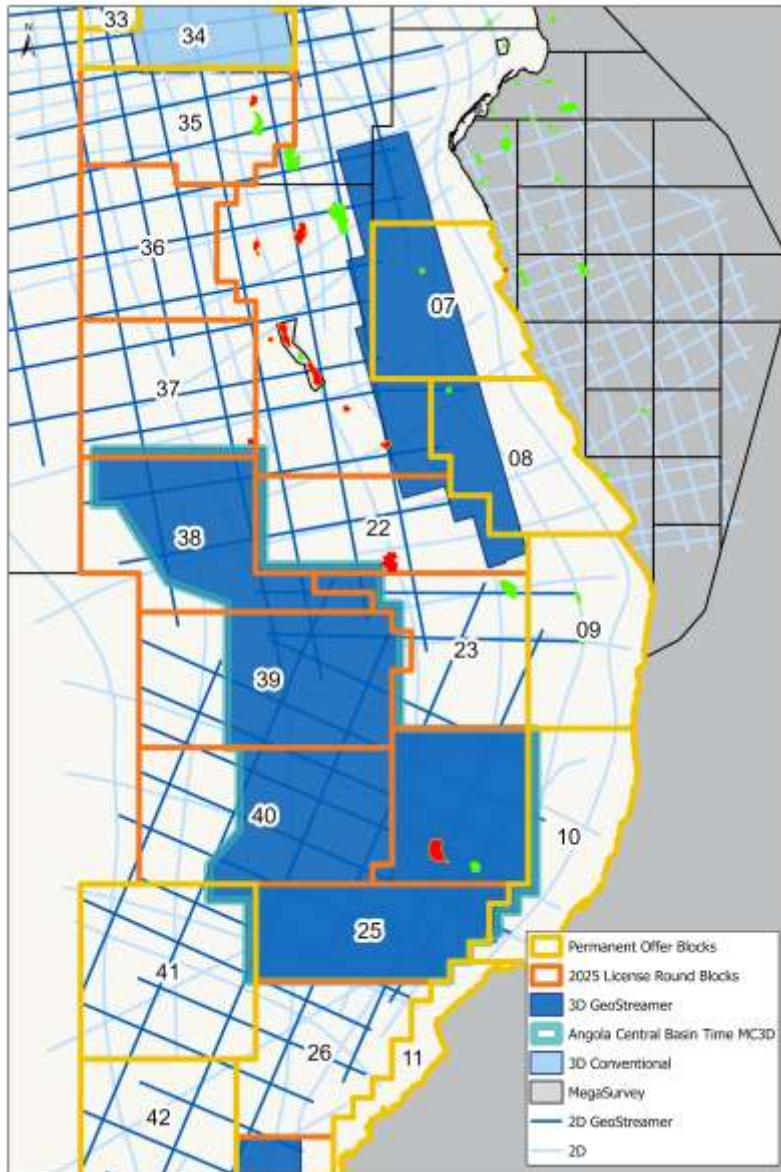
- Offshore domain contains >80% of the areal extent of the Kwanza Basin
- Water depth extends up to ~3000m in the west
- Kwanza and Benguela sub-basins
- Underexplored - only ~100 wells drilled in the offshore to date

Offshore Basin Structure



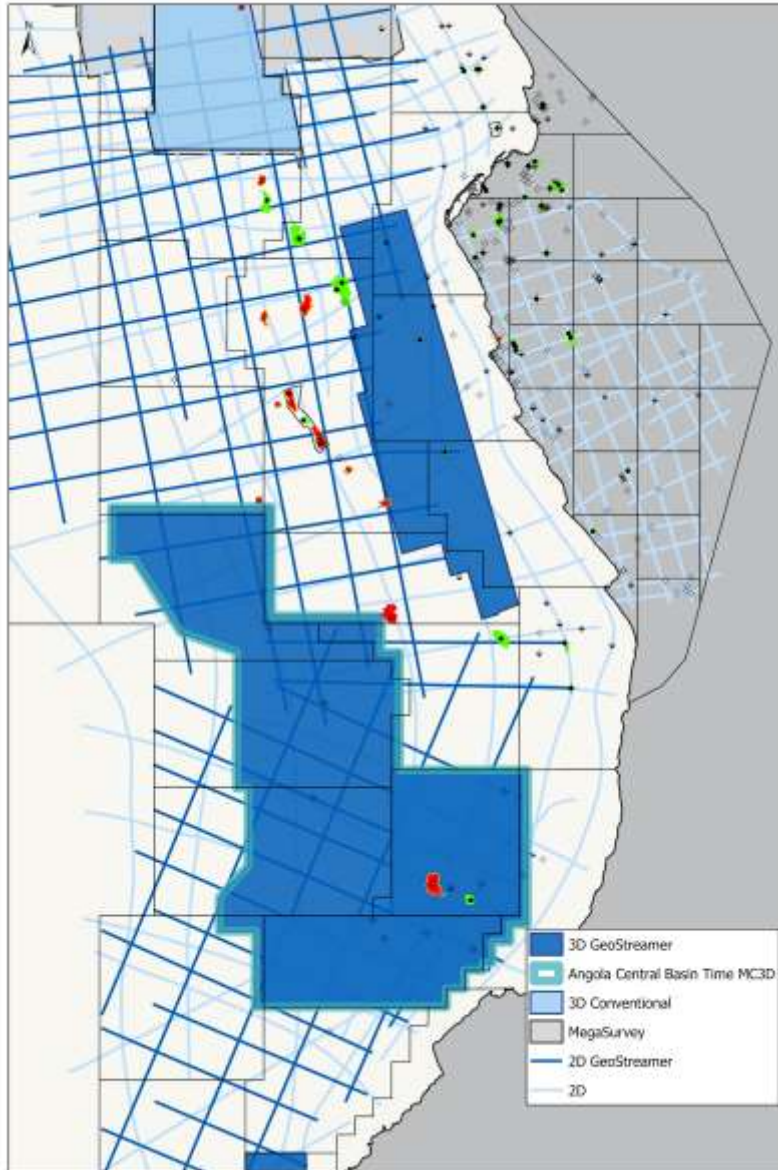
- Kwanza and Benguela sub-basins, divided by the Sumbe Volcanic line
- The offshore Kwanza is dominated by a wide continental domain, extending ~ 200 km from the present-day coastline.
- Ocean-Continent Transition bound by clear gravity low throughout Lower Congo, Kwanza and Benguela basins.

Acreage Entry Opportunities



- Permanent Offer
 - Shelfal blocks 7, 8, 9, 10, 11
 - Deep-water blocks 41, 42
- 2025 Licensing Round
 - Deep-water blocks 22, 23, 25, 26, 35, 36, 37, 38, 39, 40

Exploration History



- 1960s - onset of exploration in the offshore Kwanza
- 1980s - first sustained period of exploration - 4 successes in the shelfal region
 - Denden, Cegonha, Mubafo and Pakubalu oil discoveries
- 1990s - the pursuit of the shelf and deep-water setting post Lower Congo success
- Early 2000s - continued deep-water exploration, primarily in the post-salt
 - Semba-1 oil discovery
- 2010s - pre-salt deep-water exploration
 - Discoveries at Azul, Cameia, Katambi, Omosi plus others
- 2020s - pre-salt appraisal and near-field exploration
 - Golfinho appraisal
 - Grenadier-1 discovery well

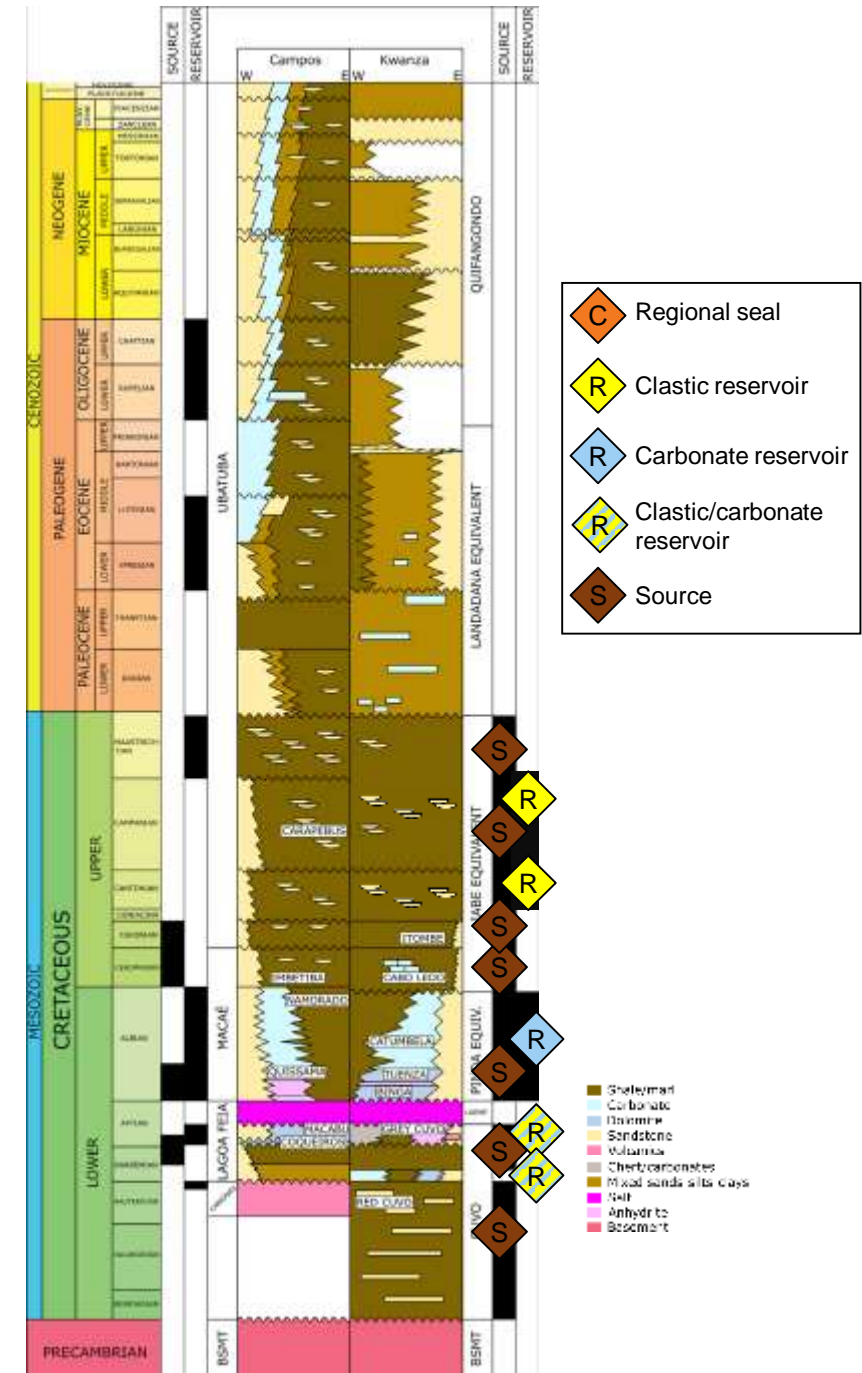
Play Elements

- Source rocks and hydrocarbon occurrences

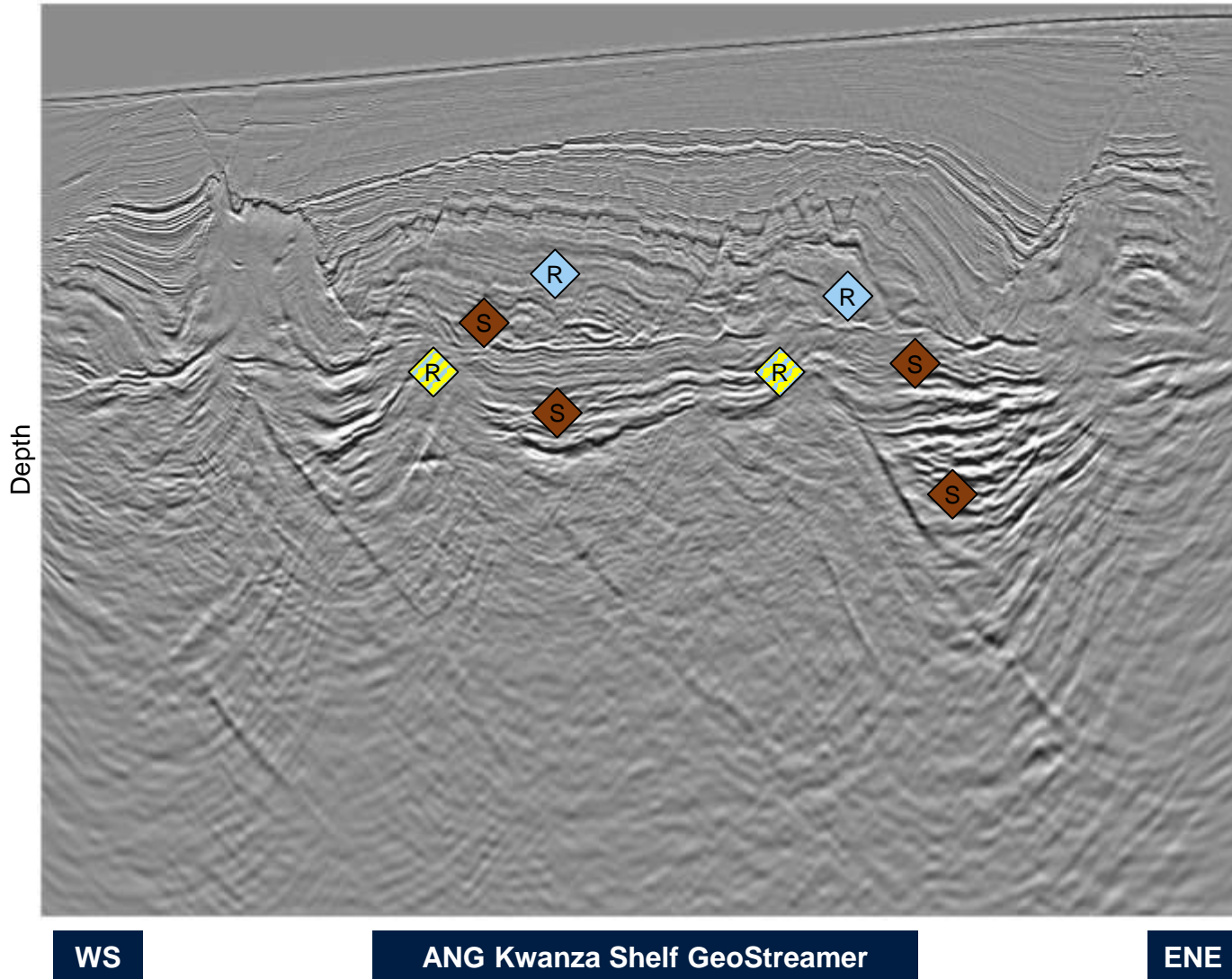
- Onshore Albian through to Maastrichtian marine oil prone carbonate facies (>6% TOC and HI >600)
- Five post-salt units proven in the shelfal area (<6.3% TOC and HI <830); excellent quality oil-prone source rocks encountered in Albian, Cenomanian-Turonian and Senonian section in deep-water (<10% TOC and HI ~600).
- Immediate pre-salt marginal marine/saline lacustrine (Falcão-1 >200m thick, TOC 3-6% but as high as 9.5%; oils in Ametista-1 and Quiteta-1)
- Pre-salt lacustrine proven (Denden-1 and Azul-1 oils)

- Reservoirs

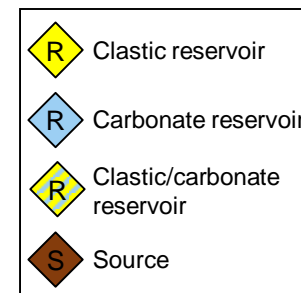
- Upper Cretaceous to Tertiary clastic turbidite systems interpreted on seismic; proven at Semba
- Albian Catumbela, Tuenza and Binga formations (Pinda play) – oolitic shoals and dolomites
- Proven pre-salt dolomites, microbial chert build-ups, shrubby boundstones and coquinas, along with thick pre-salt sands.



Kwanza Shelf Prospectivity Permanent Offer Acreage



- Albian “Pinda” play rafts
- Tilted fault blocks and base salt closures, much like Cameia and other discoveries in Block 20

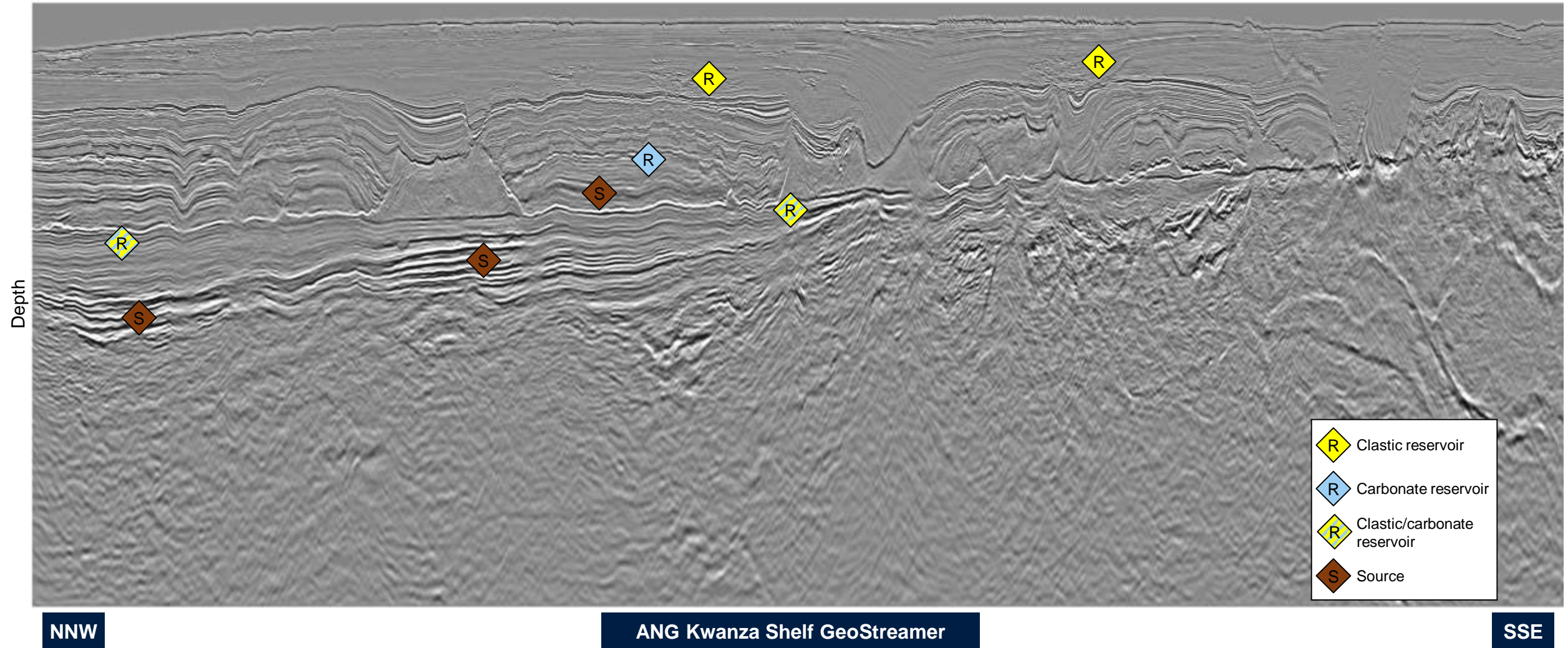


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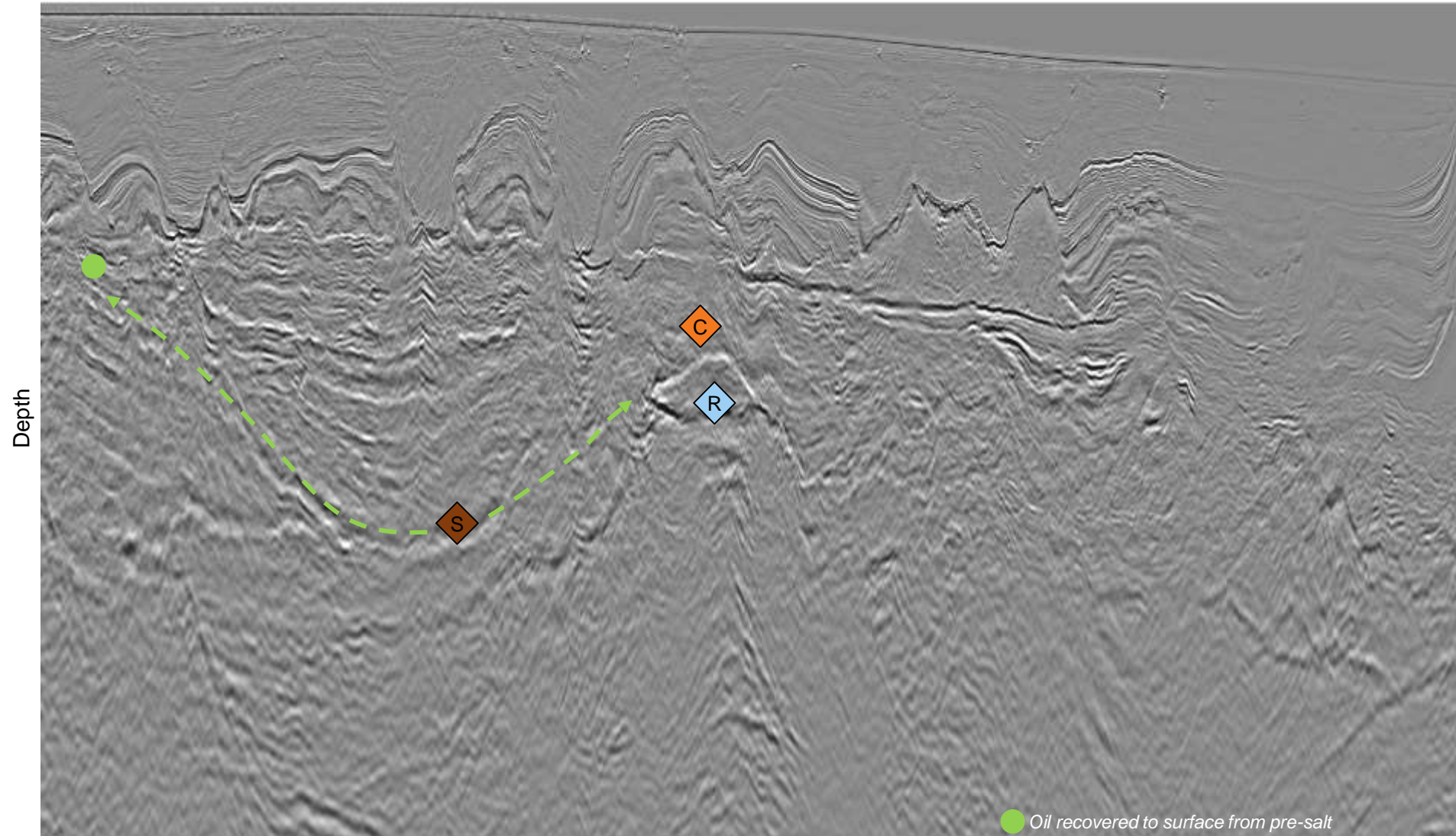
ANG Kwanza Shelf GeoStreamer

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Kwanza Shelf Prospectivity Permanent Offer Acreage

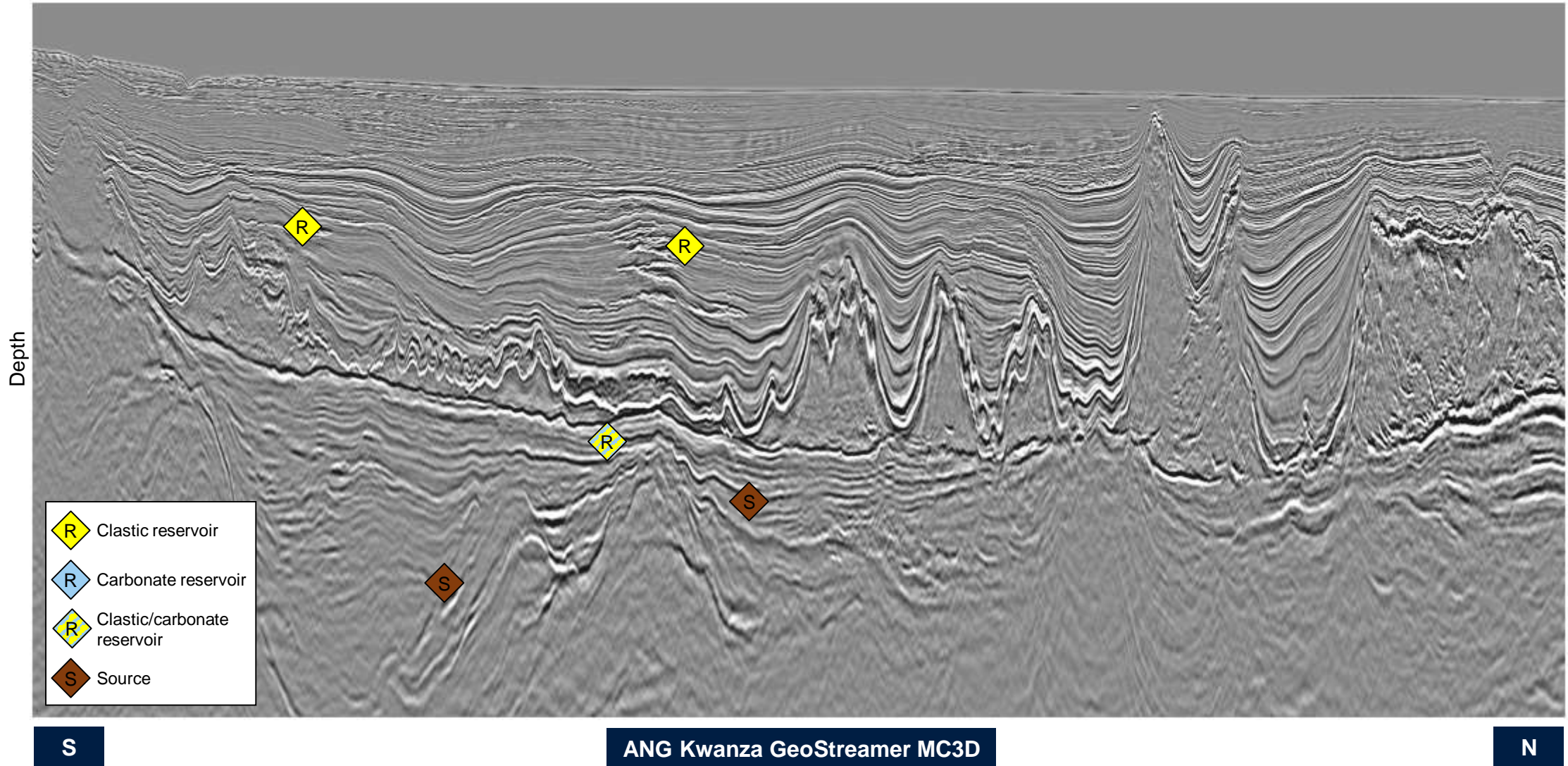


Kwanza Shelf Prospectivity: A New Potential Play Permanent Offer Acreage

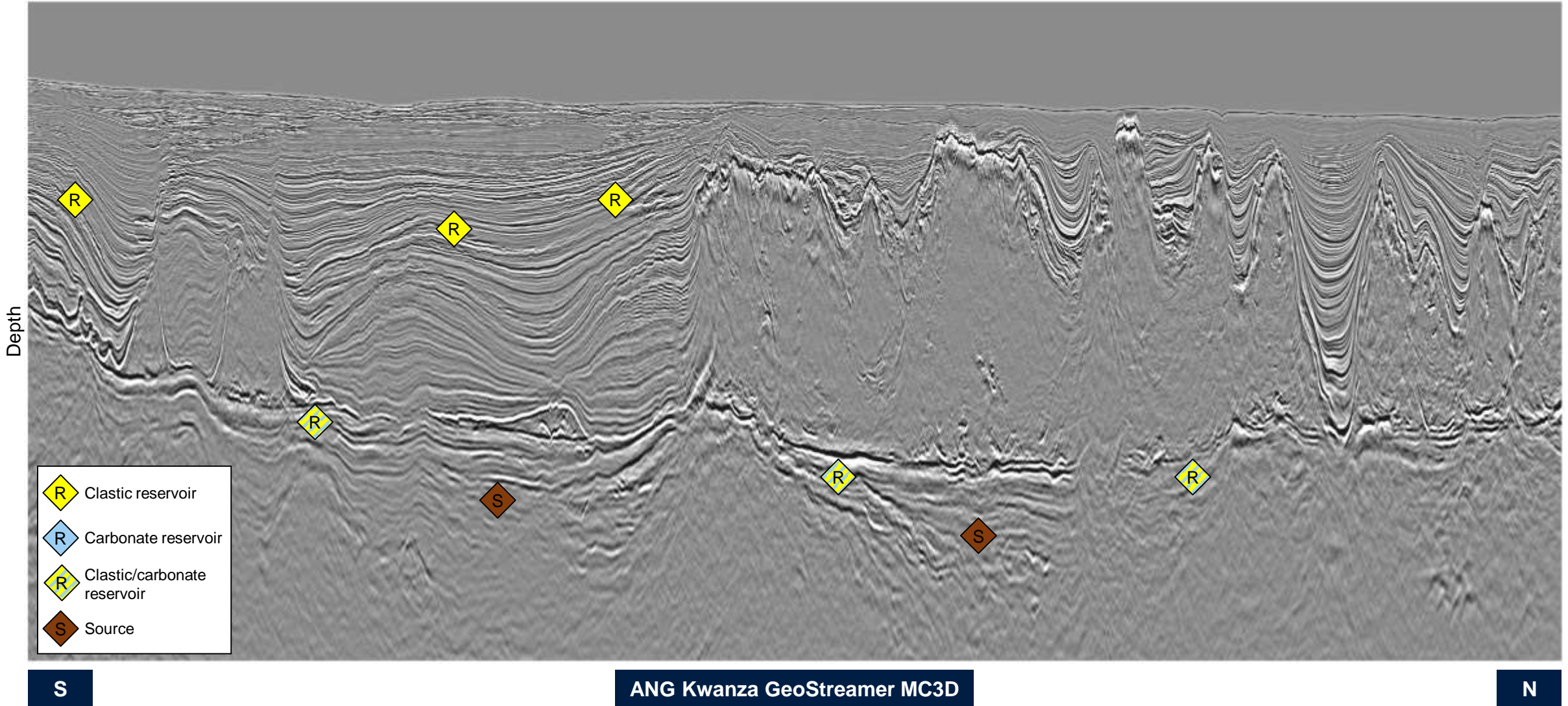


- Regional seal
- Carbonate reservoir
- Source

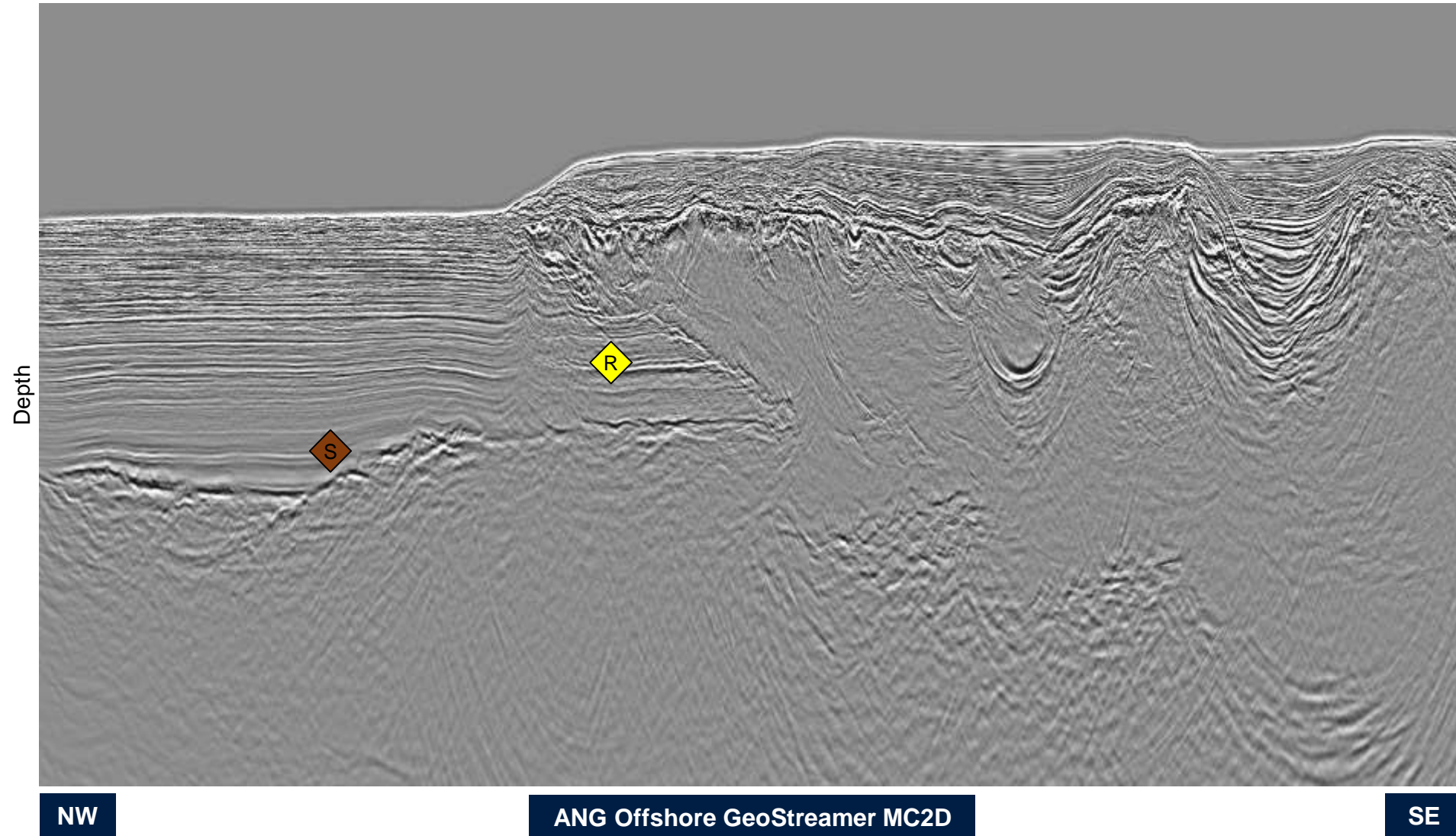
Kwanza Deep Water Prospectivity 2025 License Round Acreage



Kwanza Deep Water Prospectivity 2025 License Round Acreage



Kwanza Deep Water Prospectivity Permanent Offer Acreage



	Clastic reservoir
	Source

Summary - Onshore Kwanza



- The basin contains proven petroleum systems and a demonstrated continuation of the well understood offshore system.
- Existing wells were almost exclusively targeting post-salt units.
- Out of 182 E&A wells there are only 28 that penetrated the pre-salt, with the majority reaching TD <100m into that section. Multiple wells display oil shows in the pre-salt interval.
- Potential exists within rafted fault blocks in the Albian and faulted Upper Cretaceous, pre-salt tilted fault blocks (clastic) and pre-salt carbonates on basement highs. Exploration success has been demonstrated in pre-salt carbonates on both sides of the South Atlantic margin in last 20 years, and the onshore Kwanza has been overlooked for these targets.
- The 2010 seismic is the only modern dataset in the onshore Kwanza basin, and this is currently undergoing reprocessing with final deliverables available soon.

Summary - Offshore Kwanza



- The offshore Kwanza Basin is highly underexplored, with only 100 wells drilled offshore in an area > 105,000 sq. km.
- Hydrocarbons have been proven, both in pre- and post-salt plays, with significant potential remaining throughout both.
- Recent changes to legislation in Angola mean that gas discoveries can be monetised, and marginal fields can be developed with improved fiscal terms.
- Opportunities exist to enter acreage through the Permanent Offer regime and 2025 License Round.
- The Kaminho development on Block 20 by TotalEnergies and partners, is encouragement that success can be had in the offshore Kwanza.

Thank you



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