



Northwest Africa Atlantic Margin – MSGBC Basin Prospectivity

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Contents

- Introduction
- Geological Evolution of the MSGBC Basin
- Exploration History
- NWAAM Survey
 - Location and Acquisition
 - Play concepts and thermal modelling
 - Data Examples
 - Guinea Conakry
 - Guinea Bissau
 - AGC
 - Senegal/The Gambia
 - Mauritania
- Summary
- Conclusions



Geological Evolution of the MSGBC Basin



A topographic map of the MSGBC Basin, showing the coastline of Mauritania, Senegal, Gambia, Guinea-Bissau, and Guinea. The basin is outlined with a red dotted line. The map uses a color gradient from yellow to green to represent elevation. Major cities like Banjul, Bissau, and Conakry are marked. The Atlantic Ocean is to the west, and the equator is indicated by a dashed white line.

Mauritania, Senegal,
Gambia, Bissau, Conakry
(MSGBC)
Basin

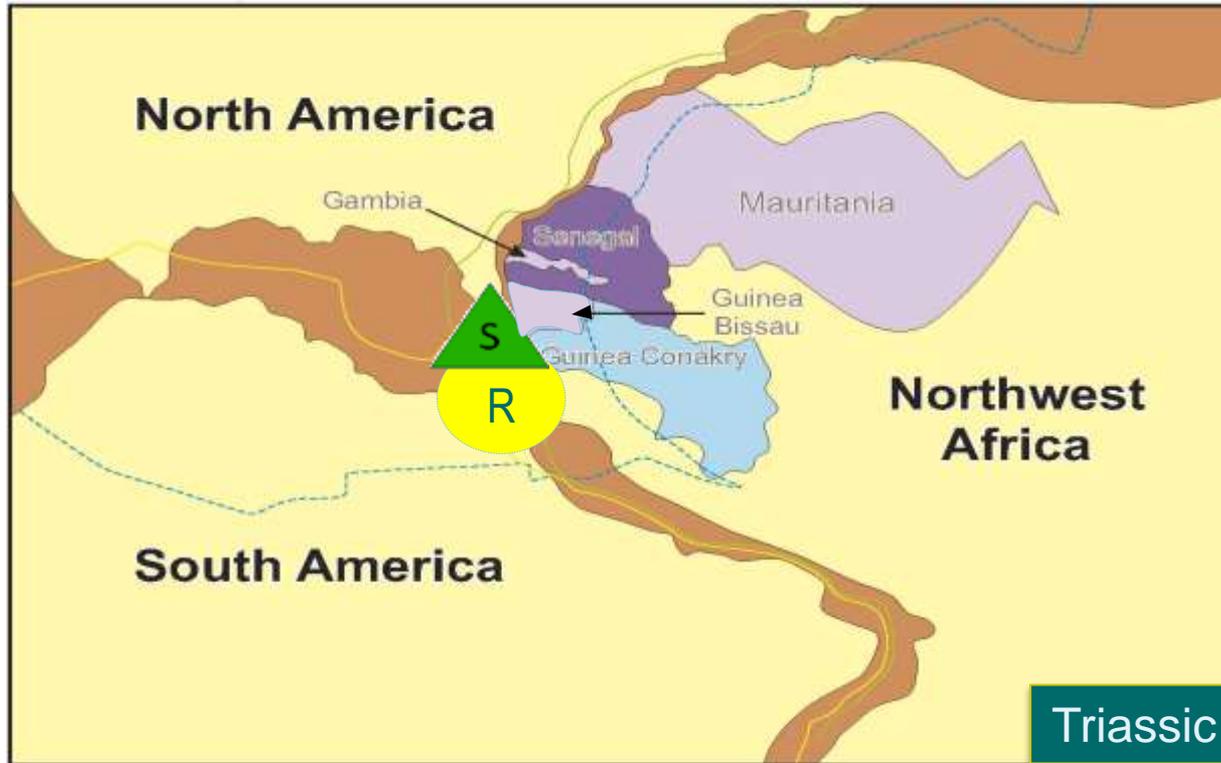


Basin Evolution

The pre-rift section is made up of:

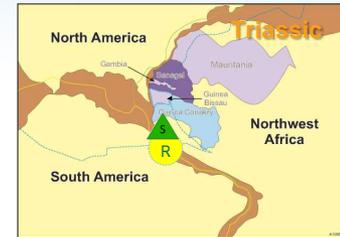
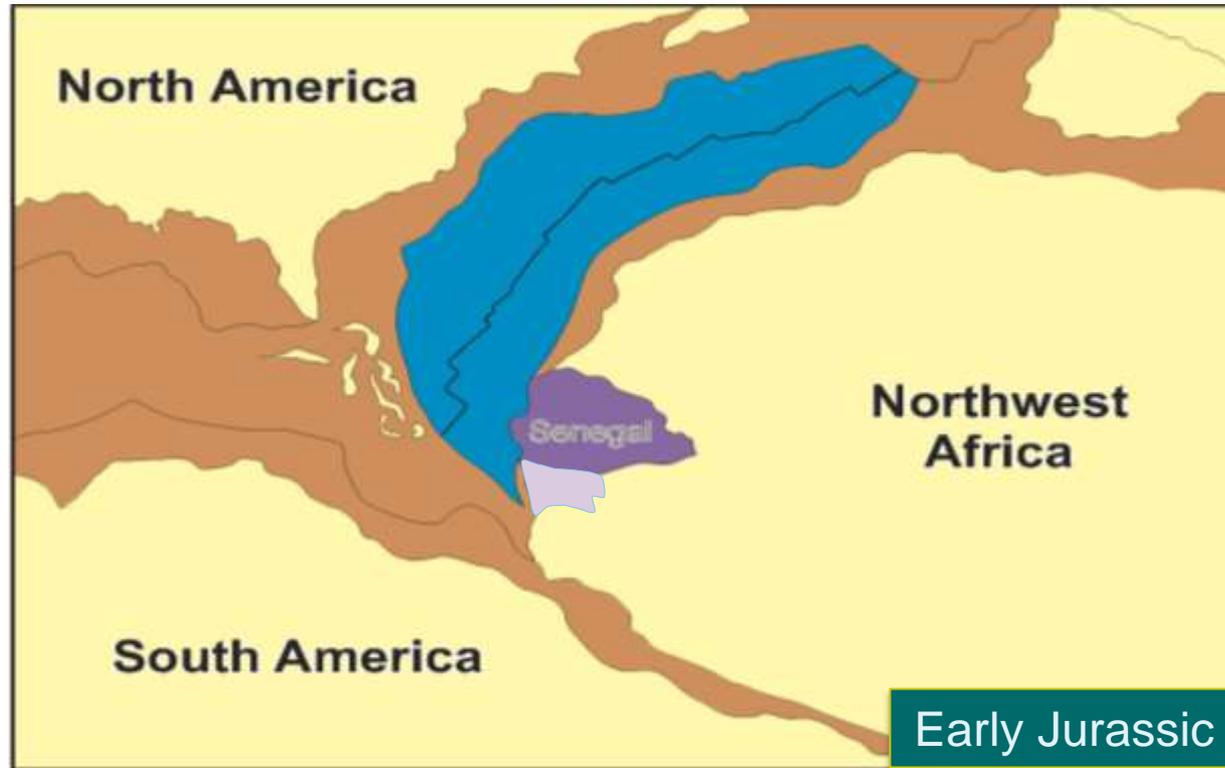
- Palaeozoic extensional tectonics in the **south** with horsts, grabens and tilted fault blocks preserved from Pre-Hercynian; and
- Compressional tectonics in the **north and central** parts of the basin with effects of Hercynian and Caledonian orogenies.

Basin Evolution



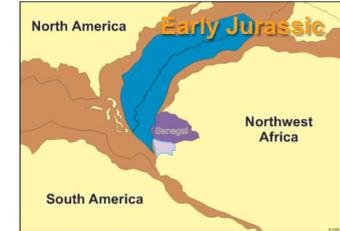
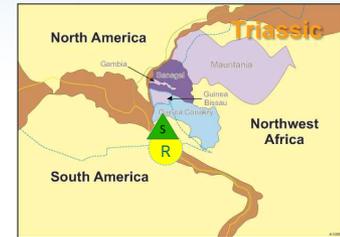
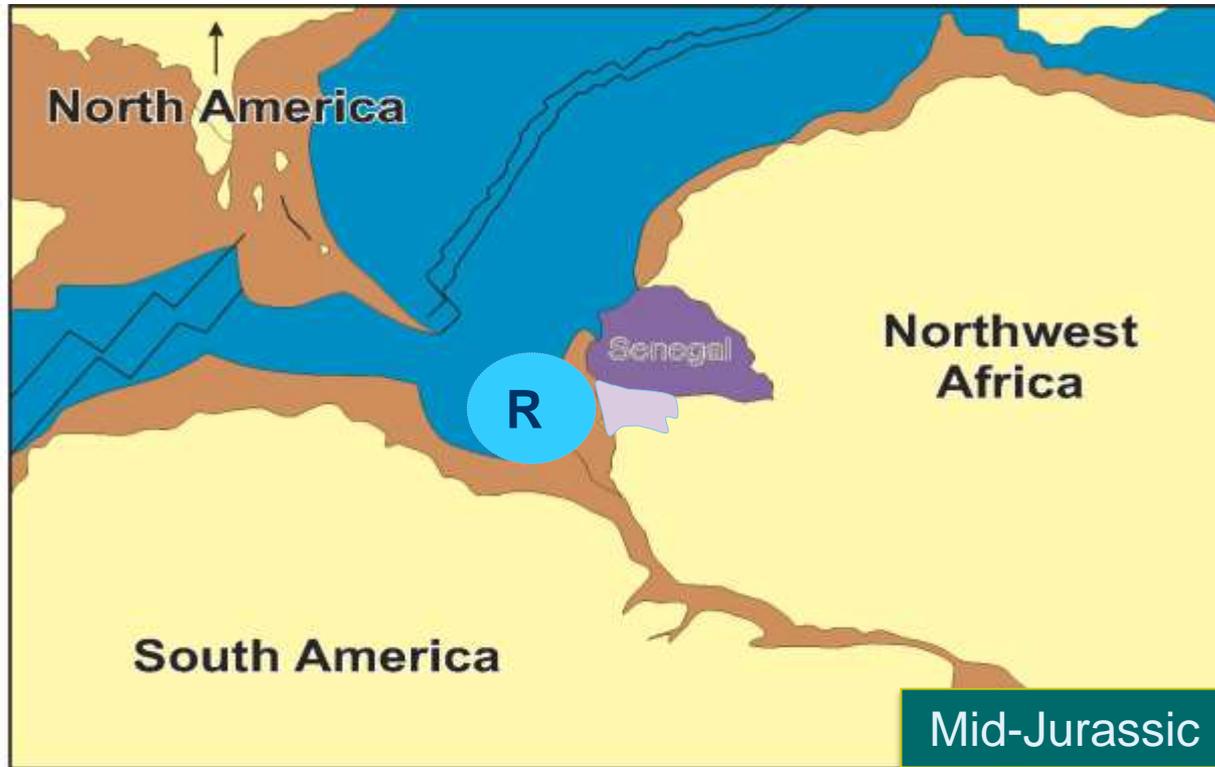
- The basin was formed at the end of the Permian in a Triassic Rift system.
- Lacustrine source rocks were deposited followed by continental Triassic clastics 1500m thick.

Basin Evolution



- A thick sequence of Triassic/Early Jurassic evaporites were deposited in the basin. Up to 2000m of salt.
- Transgressing seas brought post-rift marine sediments.

Basin Evolution



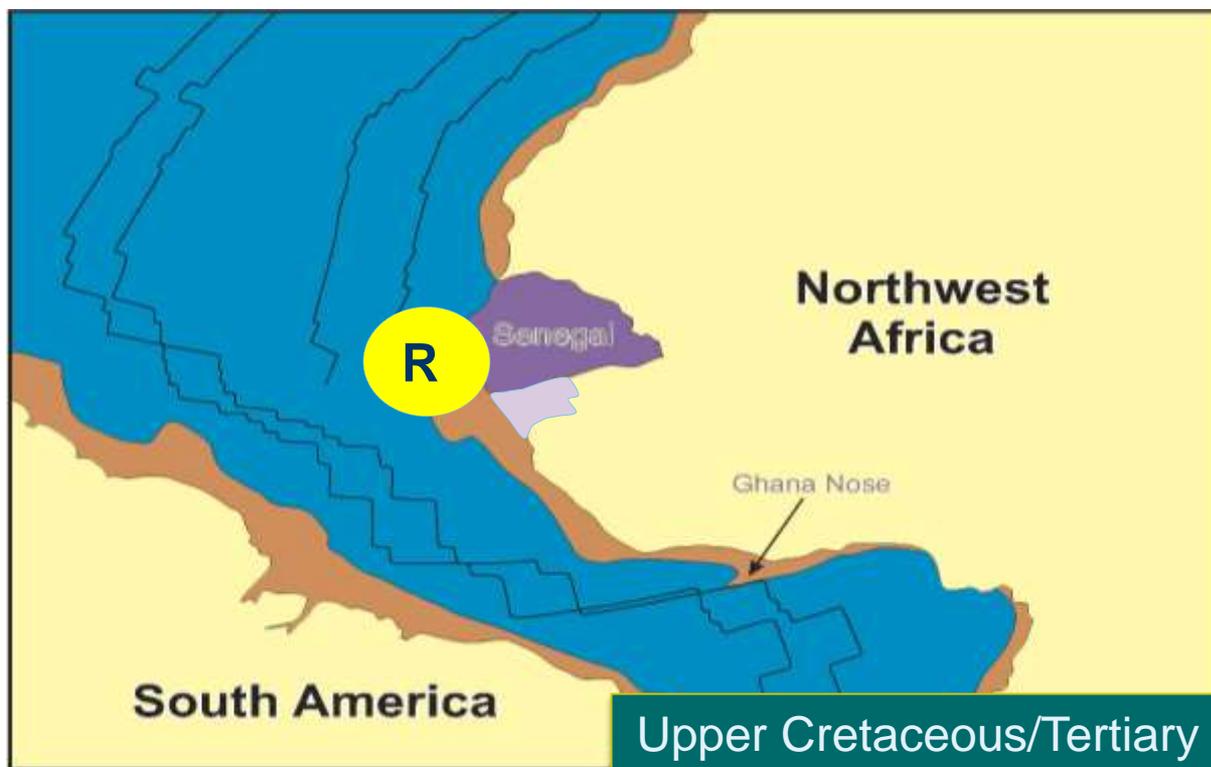
- 2000-3000m thick carbonates reservoirs were deposited from an active carbonate factory.
- The platform both prograded and regressed through time.

Basin Evolution



- Thick marine shales interbedded with marginal marine sandstones deposited after the **opening of the Atlantic** in the Cenomanian.
- Black, bituminous Turonian shales were deposited marking the maximum Cretaceous transgression

Basin Evolution



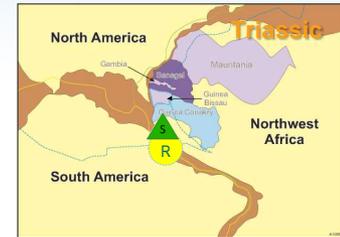
- Senonian marine regression which culminated in deposition of thick Maastrichtian sandstones. Up to 1200m thick.
- Tertiary sediments are unconformable and consist of marine shales, carbonates with influx of sandy turbidites



Basin Evolution

The Basin has undergone a complex history that can be divided into 3 main stages of development:

- the pre-rift (Precambrian to Paleozoic)
- syn-rift (Permian to Early Jurassic)
- post-rift (Middle Jurassic onwards)



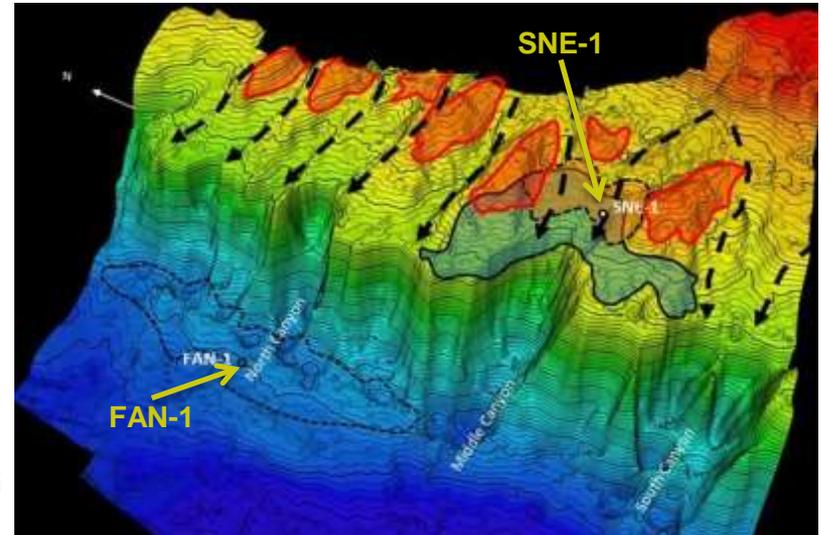
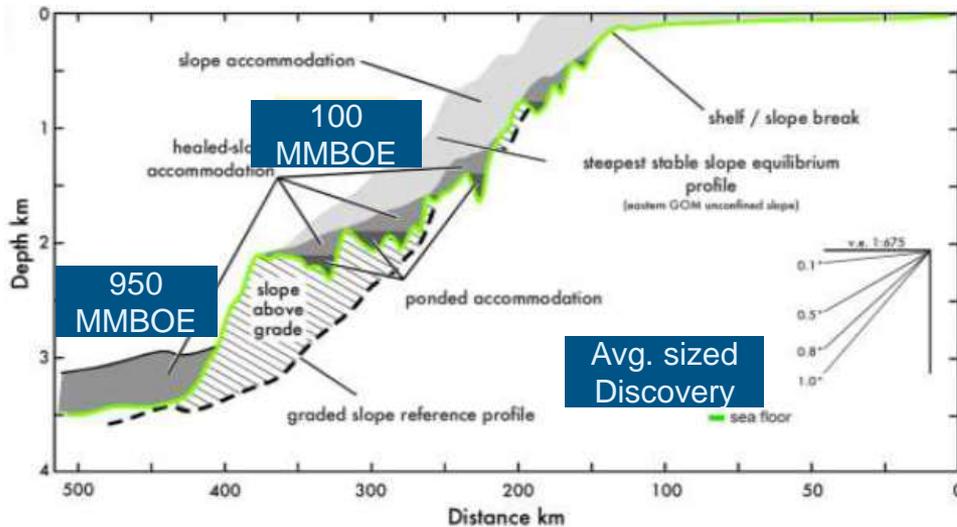


Exploration History



Drilling Summary

- To date 177 exploration wells have been drilled in the basin with 115 encountering hydrocarbons – **66%**!
- Of the 110 offshore wells:
 - only 60 are in water depth of greater than 100m;
 - only 30 in water depths greater than 1000m;
 - And only 2 in water depths greater than 2000m.



Adapted from Grant et al. 2013. Copyright SIEP BV.

(Source FAR website)

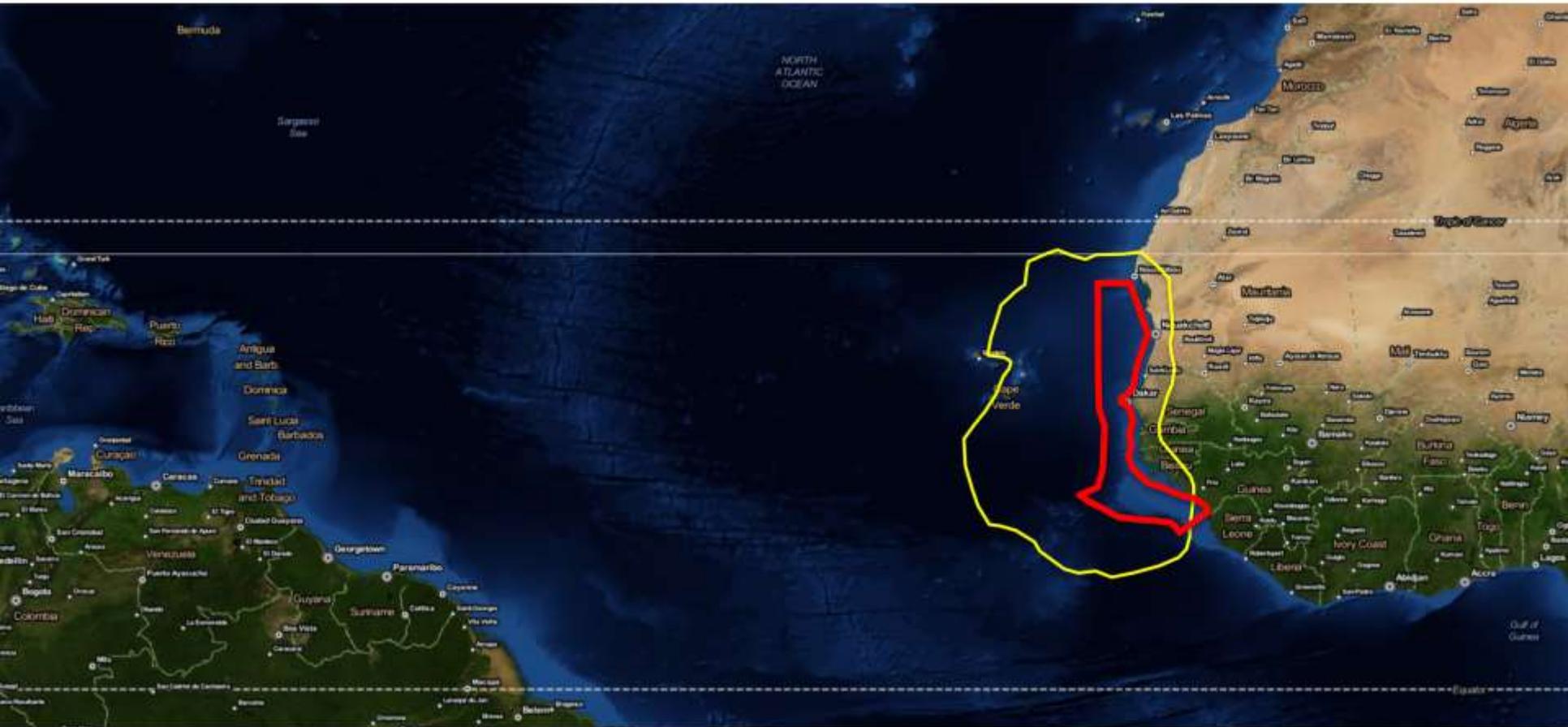


NWAAM Survey

Acquired in collaboration with:



NWAAM Survey



NWAAM Survey



NWAAM Phase 2

Acquisition
May - November 2012

Covered Area
140,000 km²

NWAAM Phase 1

Acquisition
April – October 2011

Covered Area
220,000 km²

NWAAM Survey



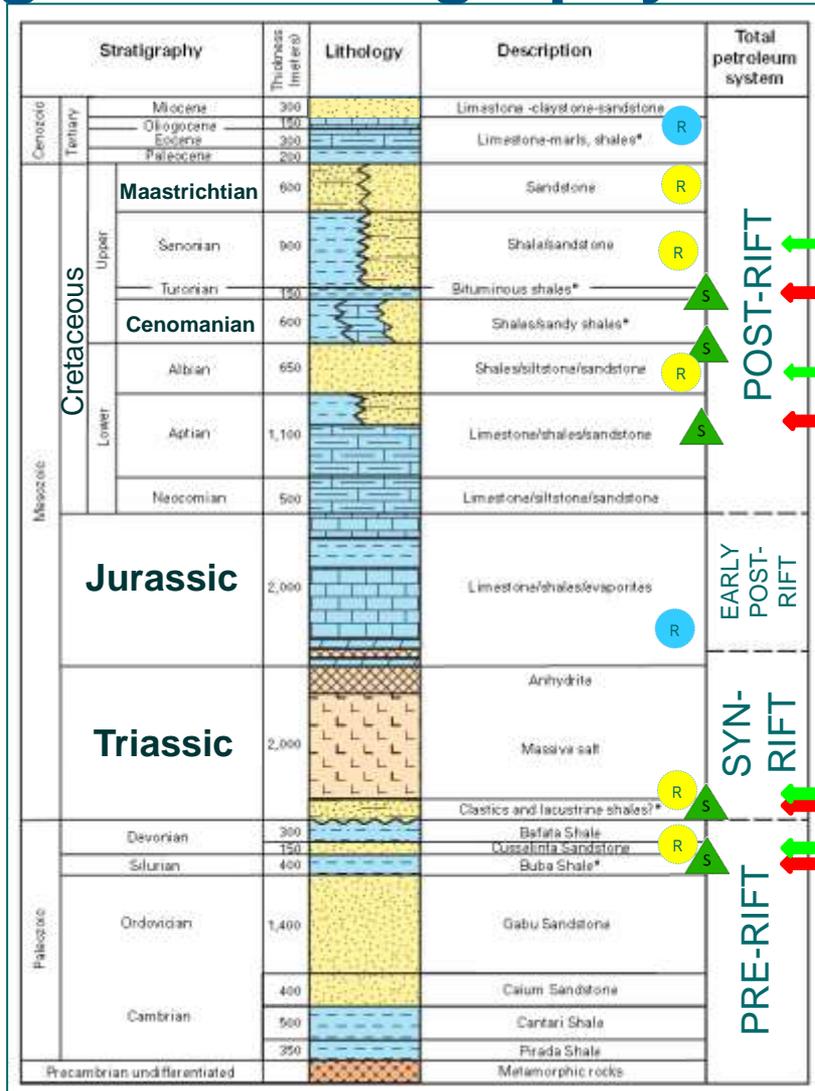
Streamer Length:
8km

Recording Chs:
640

Record Length:
14 sec (NWAAM Ph2)
9 sec (NWAAM Ph1)

More info:
<http://www.tgs.com/>

NWAAM Regional Stratigraphy



- R Limestone reservoir
- R Clastic reservoir
- ▲ S Source rocks

POST-RIFT

EARLY POST-RIFT

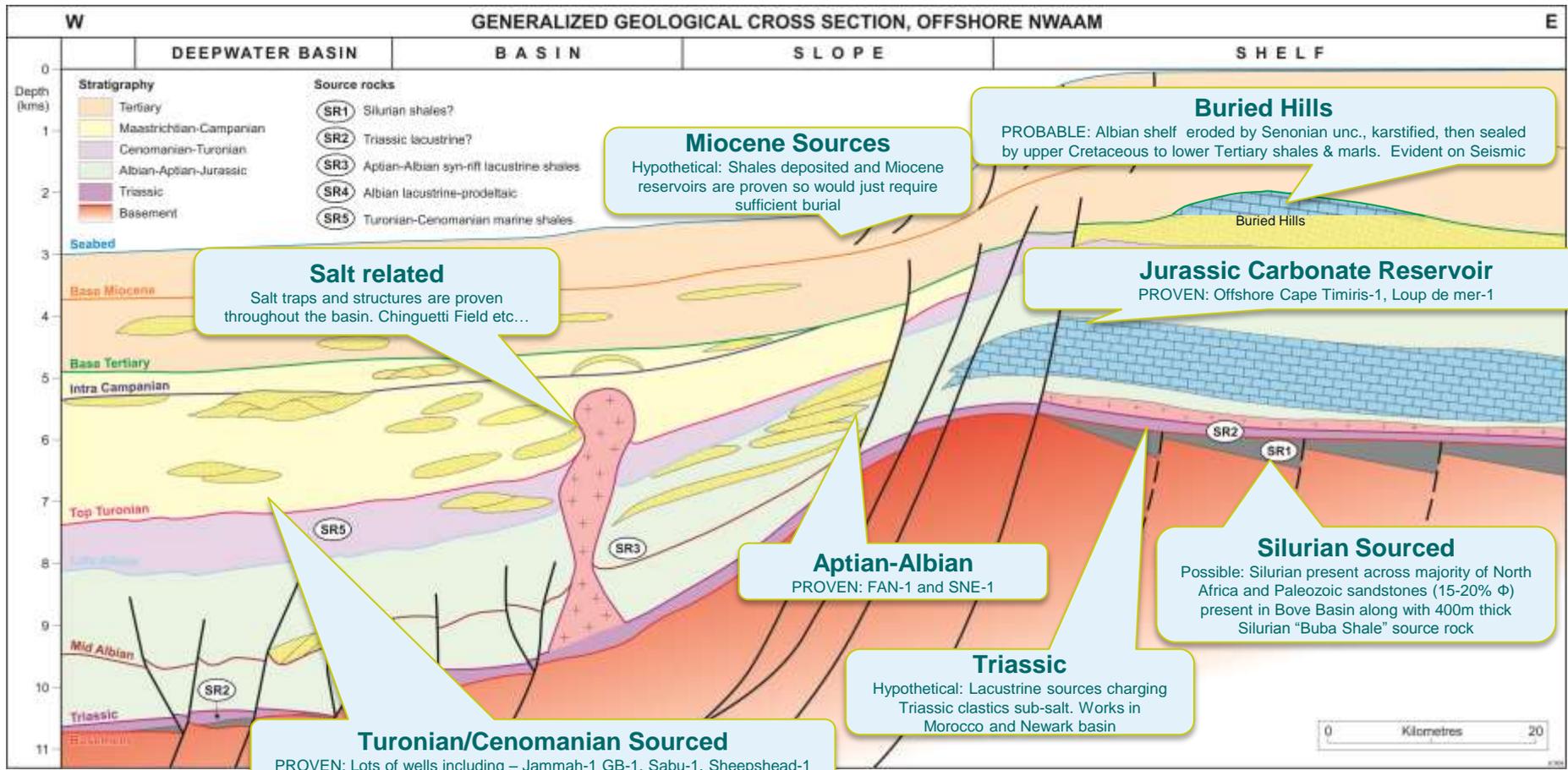
SYN-RIFT

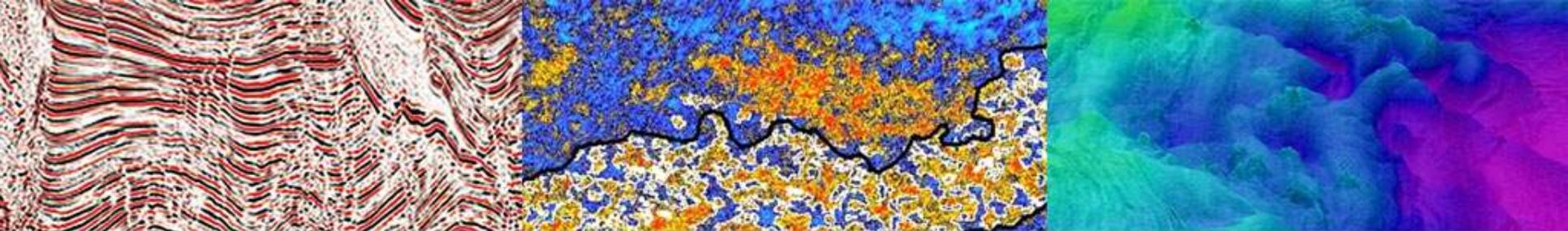
PRE-RIFT

- ← Cretaceous – Tertiary RESERVOIR
- ← Cenomanian / Turonian MARINE SOURCE ROCK
- ← Albian RESERVOIR
- ← Aptian MARINE SOURCE ROCK
- ← Triassic RESERVOIR
- ← Triassic LACUSTRINE SOURCE ROCK ?
- ← Devonian RESERVOIR
- ← Silurian MARINE SOURCE ROCK ?

M. Brownfield and R. Charpentier, 2003

Play Concepts



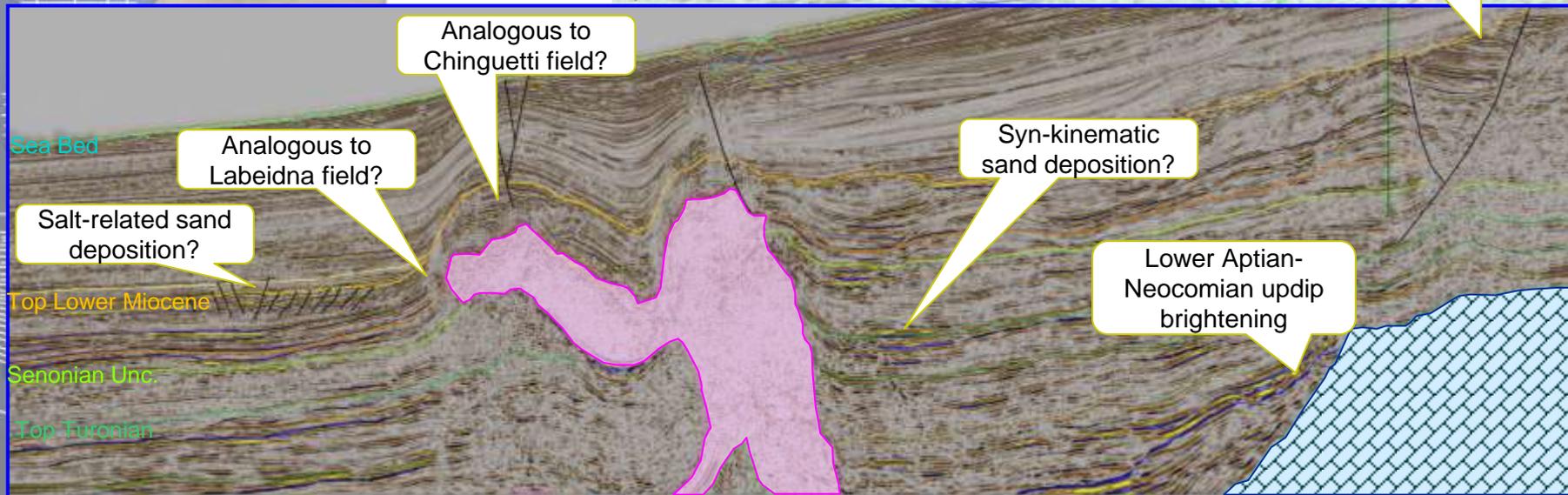
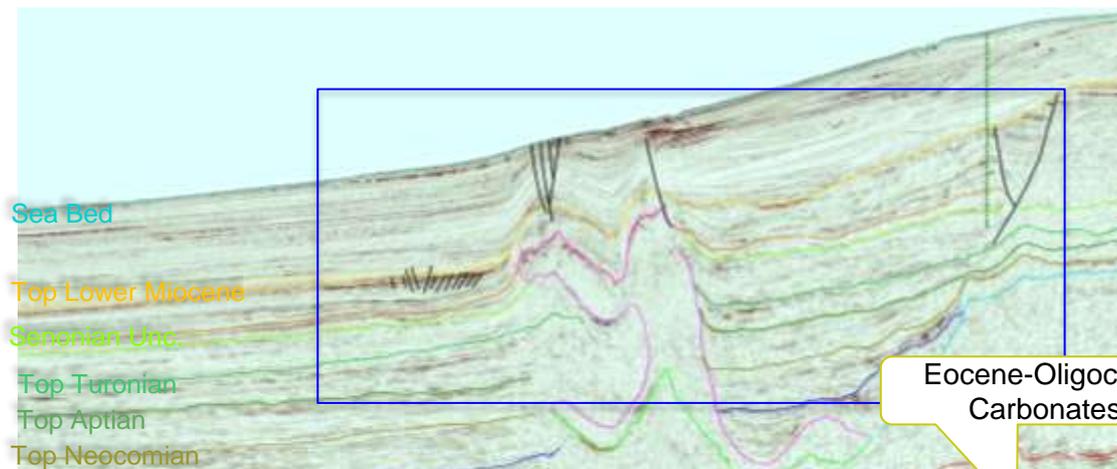


NWAAM Data Play Examples

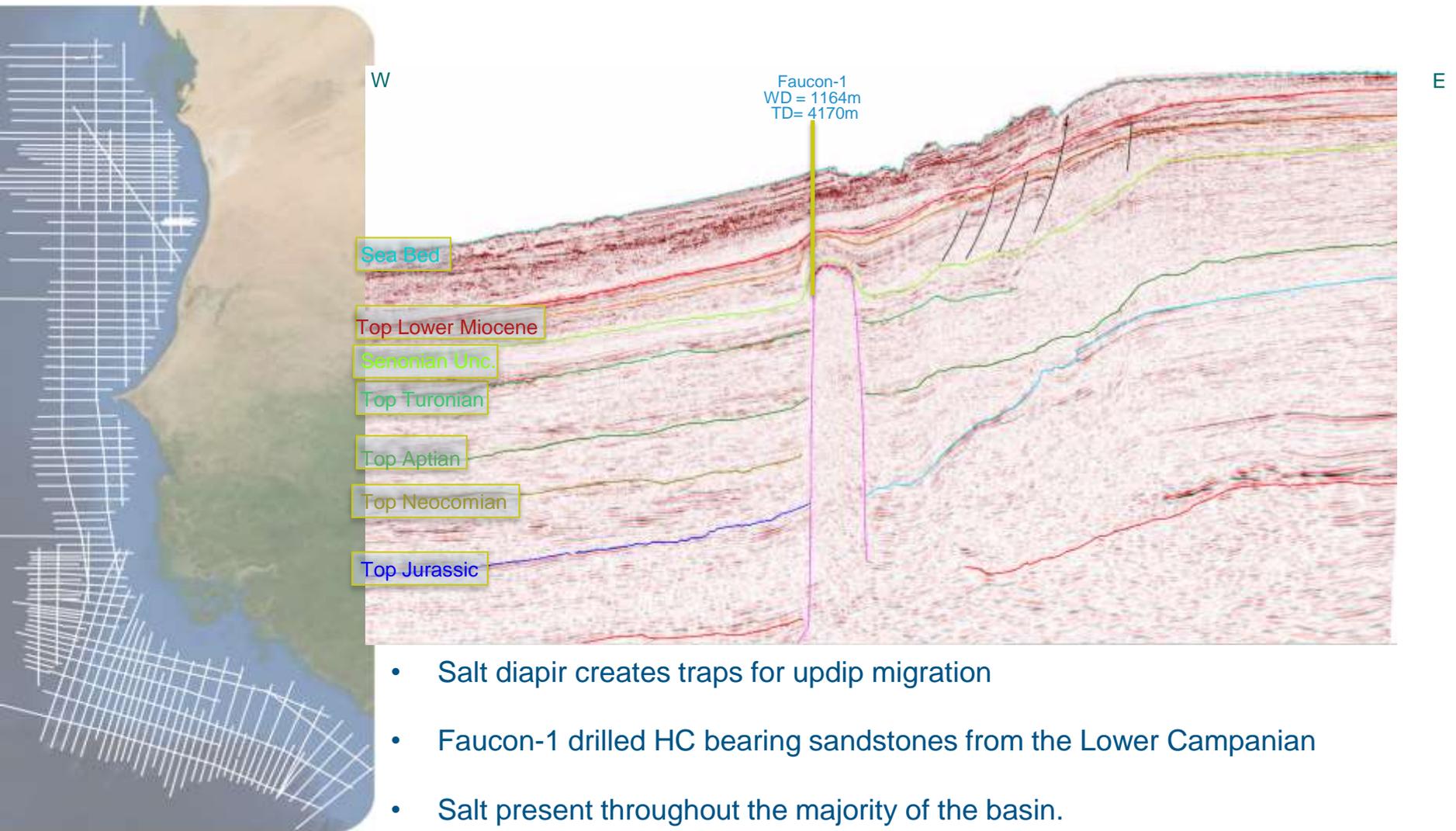


NWAAM - Mauritania Sub Basin

Coppolani-1



NWAAM – Southern Mauritania Sub Basin



NWAAM – Sangomar Basin

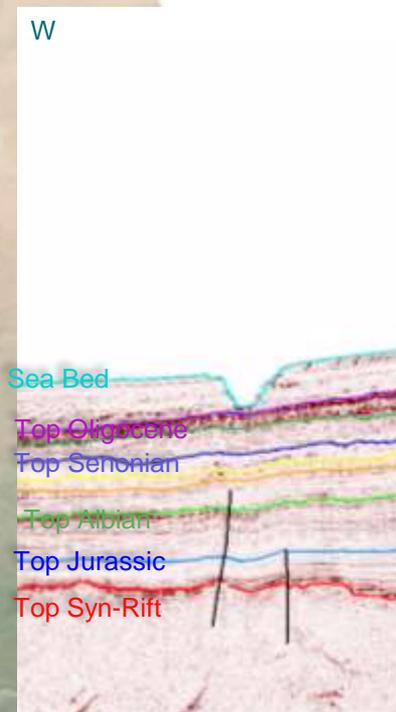
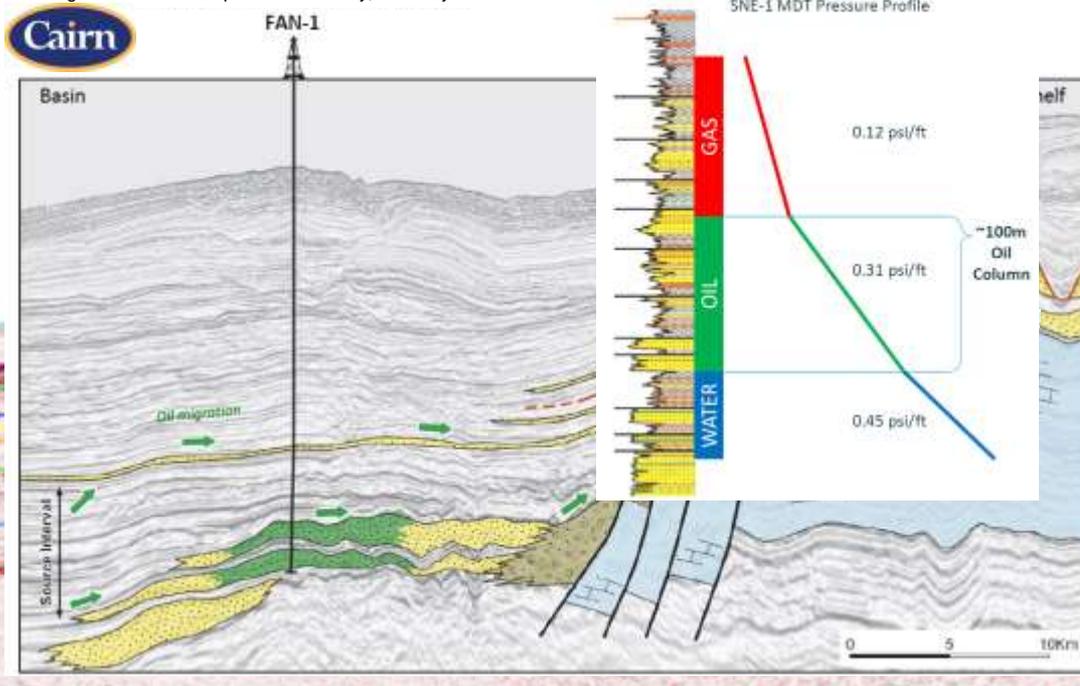
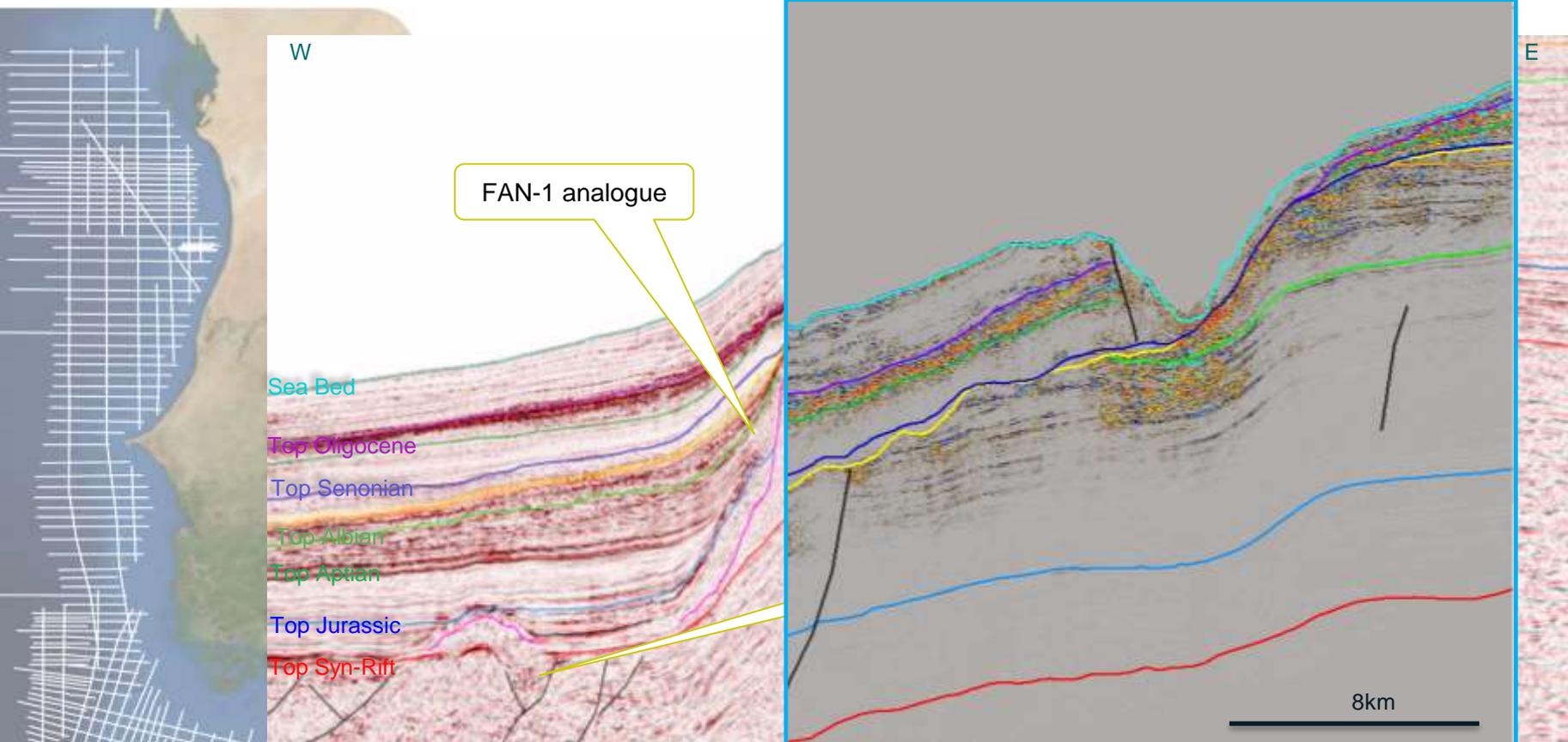


Image credit: Cairn Capital Markets Day, 11th May 2015



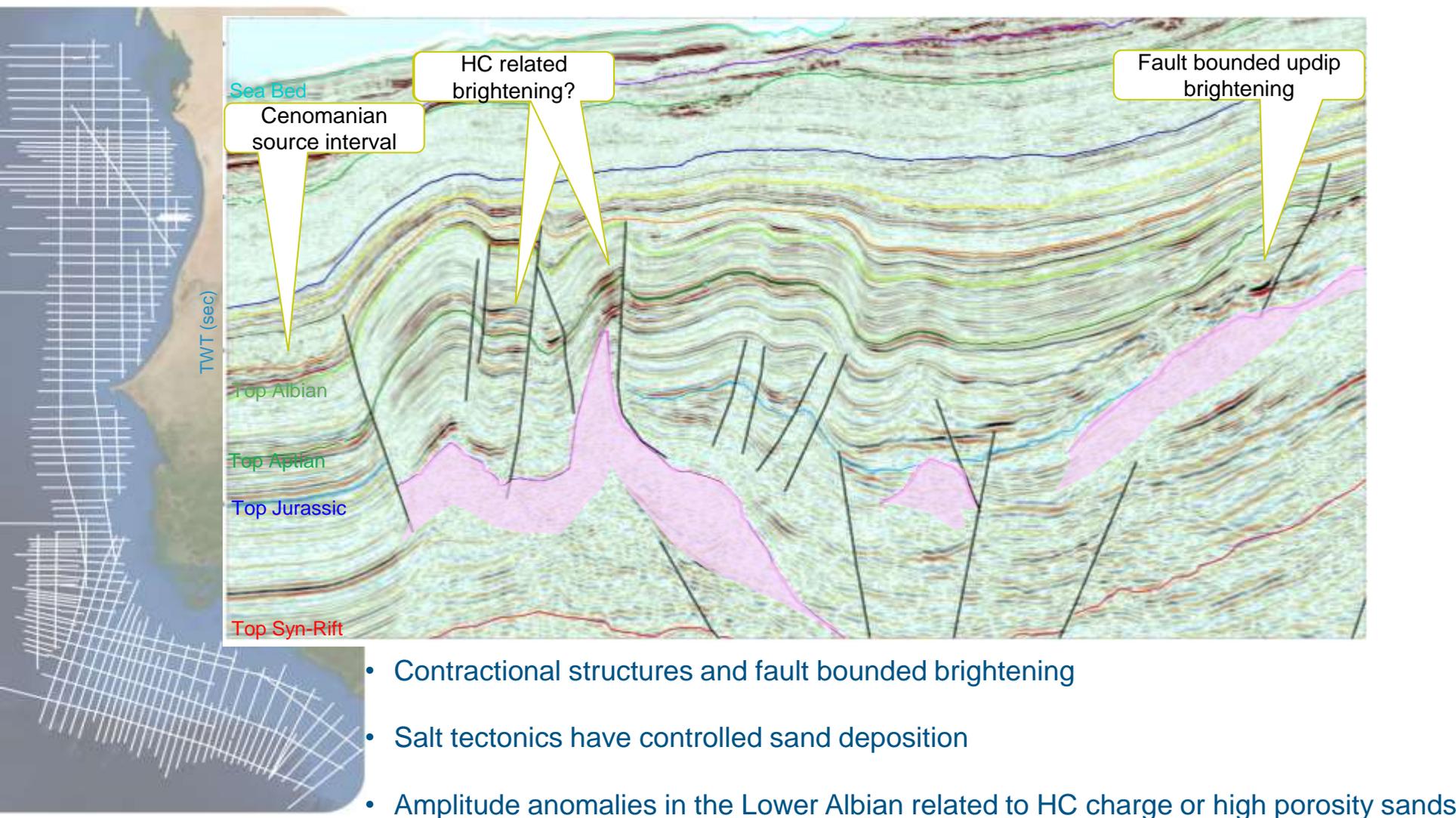
- 2 recent discoveries in the basin, both Albian sandstone reservoirs sourced from Aptian sources.
- FAN-1 is a set of stack fans
- SNE-1 - 96 metre oil column in 24% PHIE shelf edge sands
- FAN-1 & SNE-1 have a combined p-50 reserve estimate of over a Billion barrels of Oil of API 32°

NWAAM – Casamance Basin

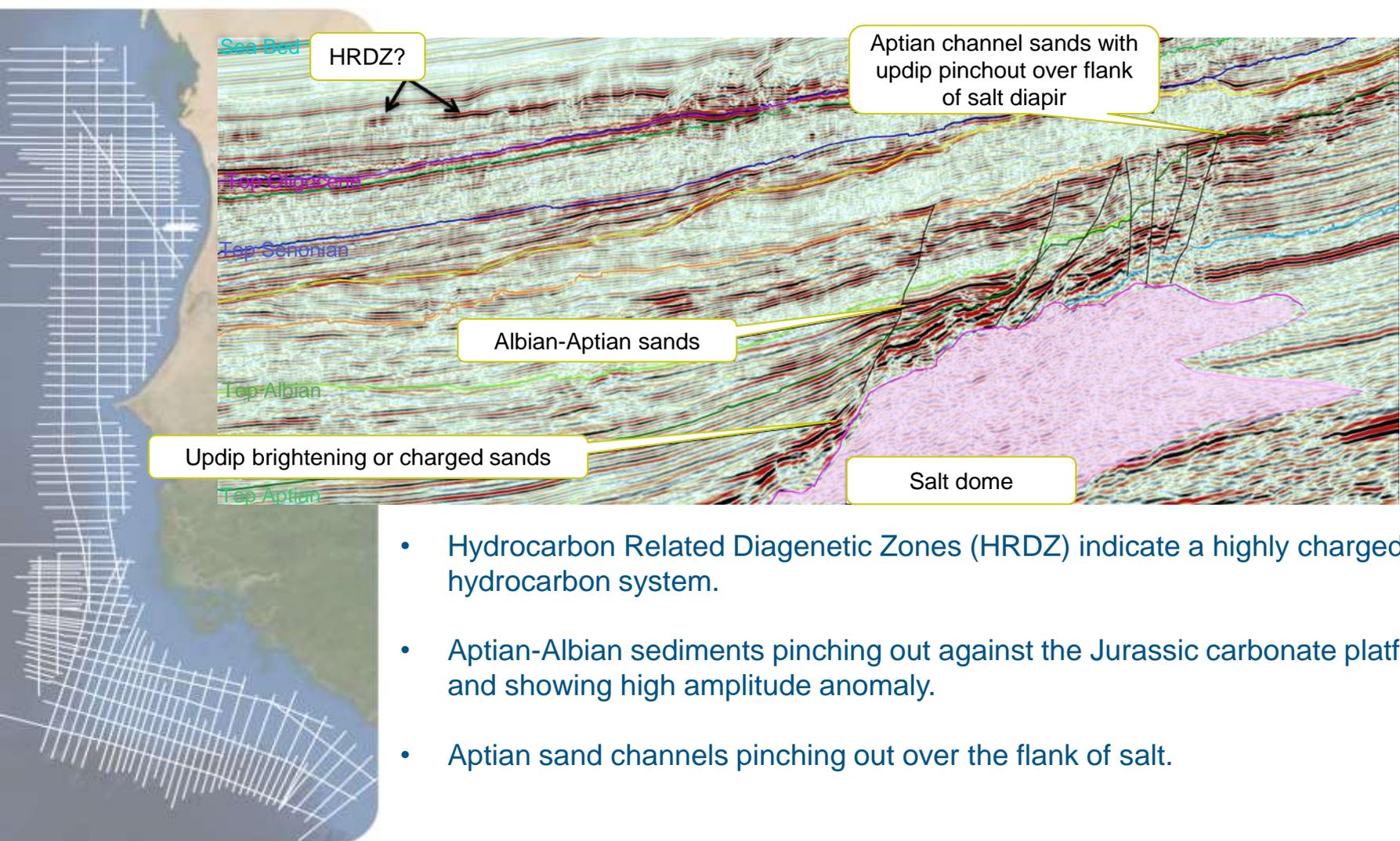


- Similar structuration to Sangomar basin despite being 150km further south
- SNE-1 analog further up-dip which has an AVO response showing stacked sands.
- Salt dome post-salt clastic play?
- Evidence of Pre-salt Triassic play

NWAAM - Casamance Sub Basin (AGC)

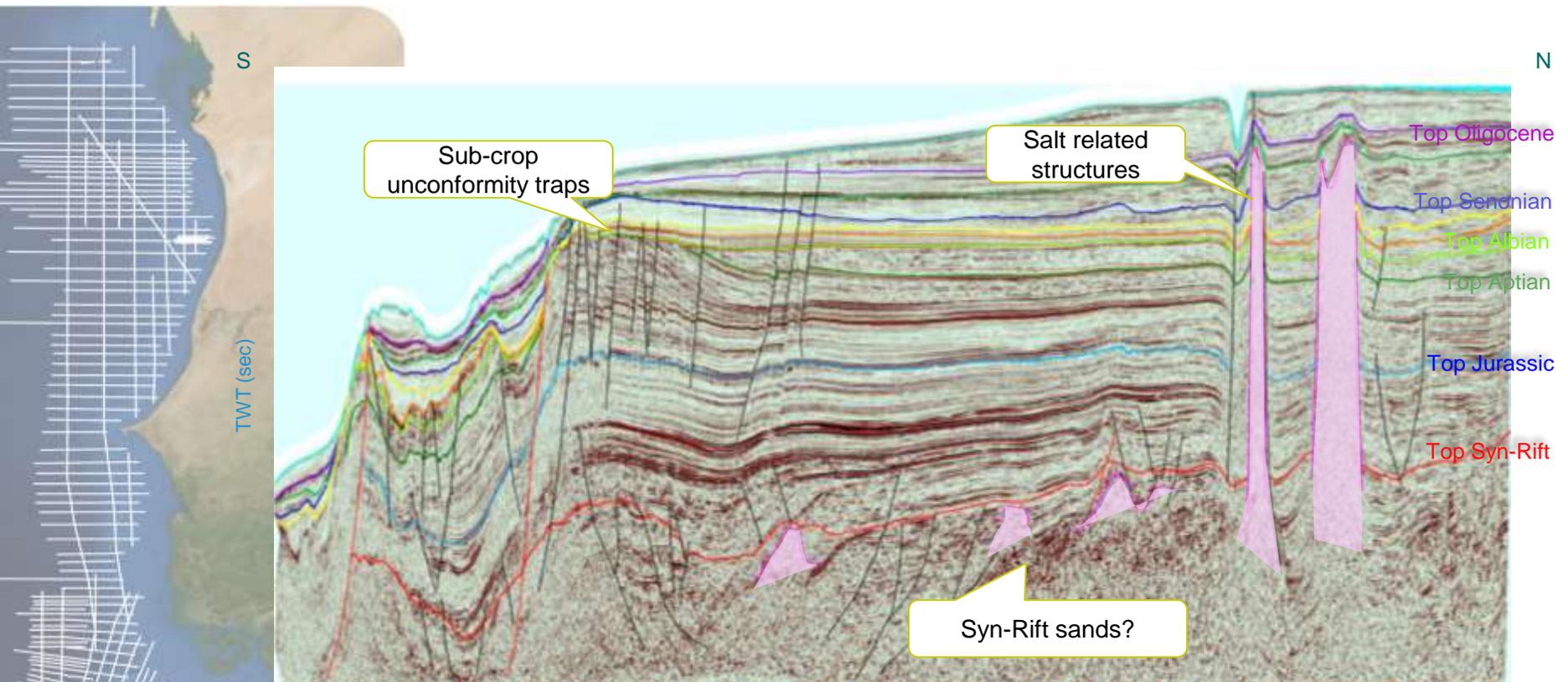


NWAAM - Southern Sub Basin (Guinea Bissau)



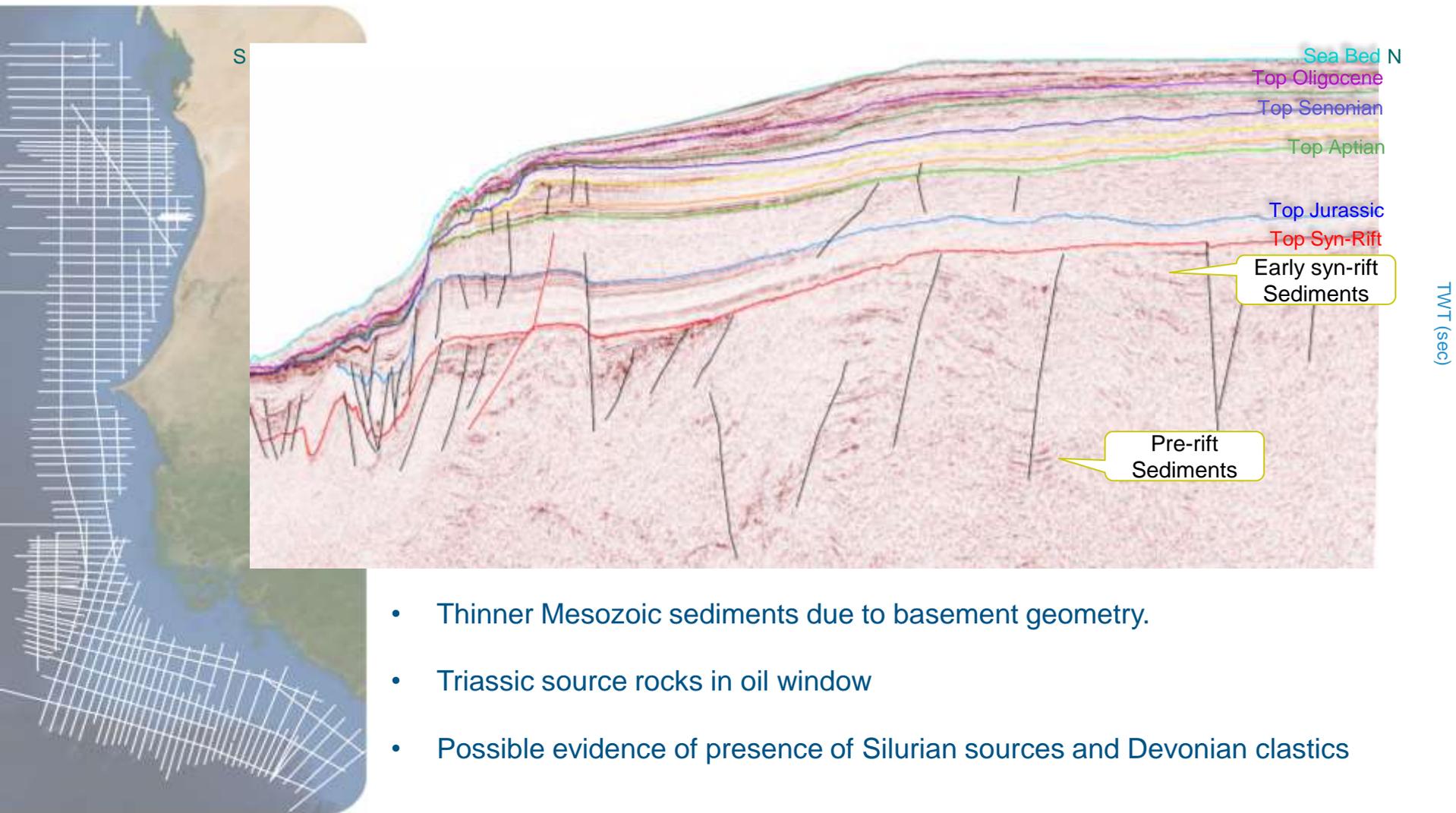
- Hydrocarbon Related Diagenetic Zones (HRDZ) indicate a highly charged hydrocarbon system.
- Aptian-Albian sediments pinching out against the Jurassic carbonate platform and showing high amplitude anomaly.
- Aptian sand channels pinching out over the flank of salt.

NWAAM - Southern Sub Basin (Guinea Bissau)

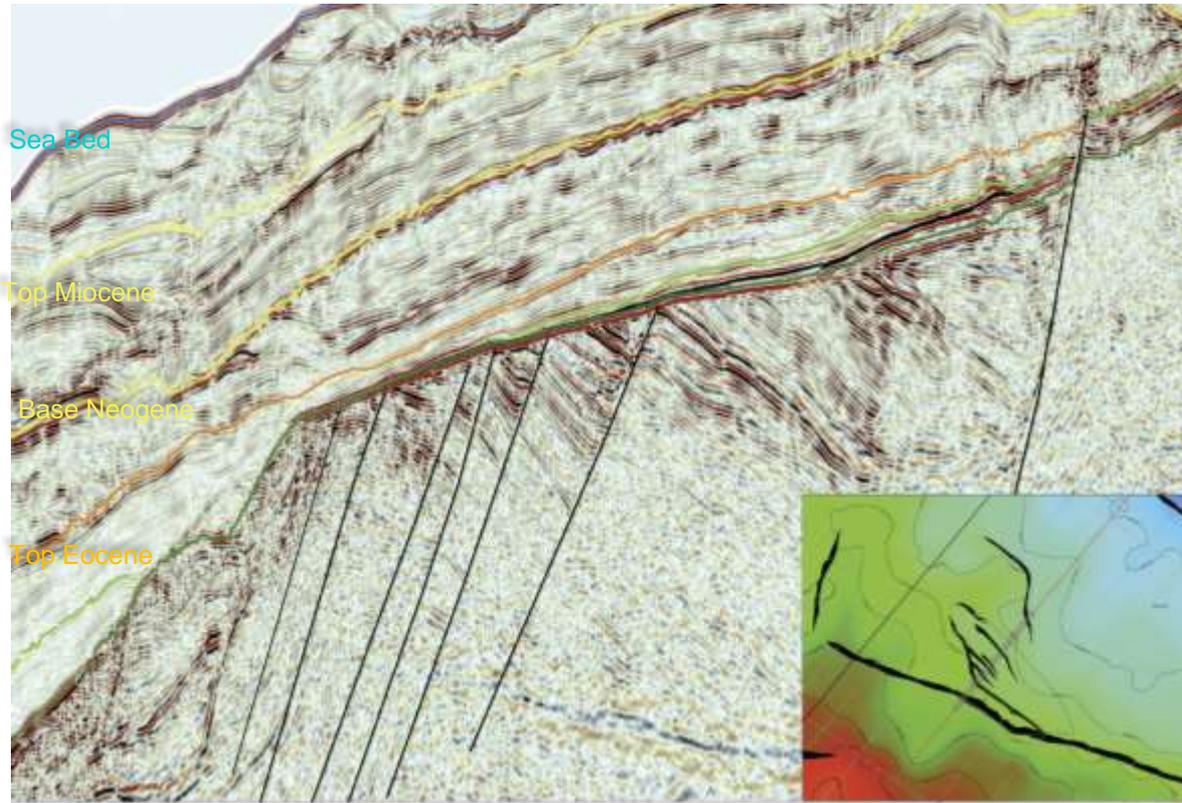


- Diapir piercing Late Cretaceous sediments.
- shallow water sub-crop unconformity traps at the edge of the hinge zone.
- syn-rift sands below the salt.

NWAAM - Offshore Guinea Conakry



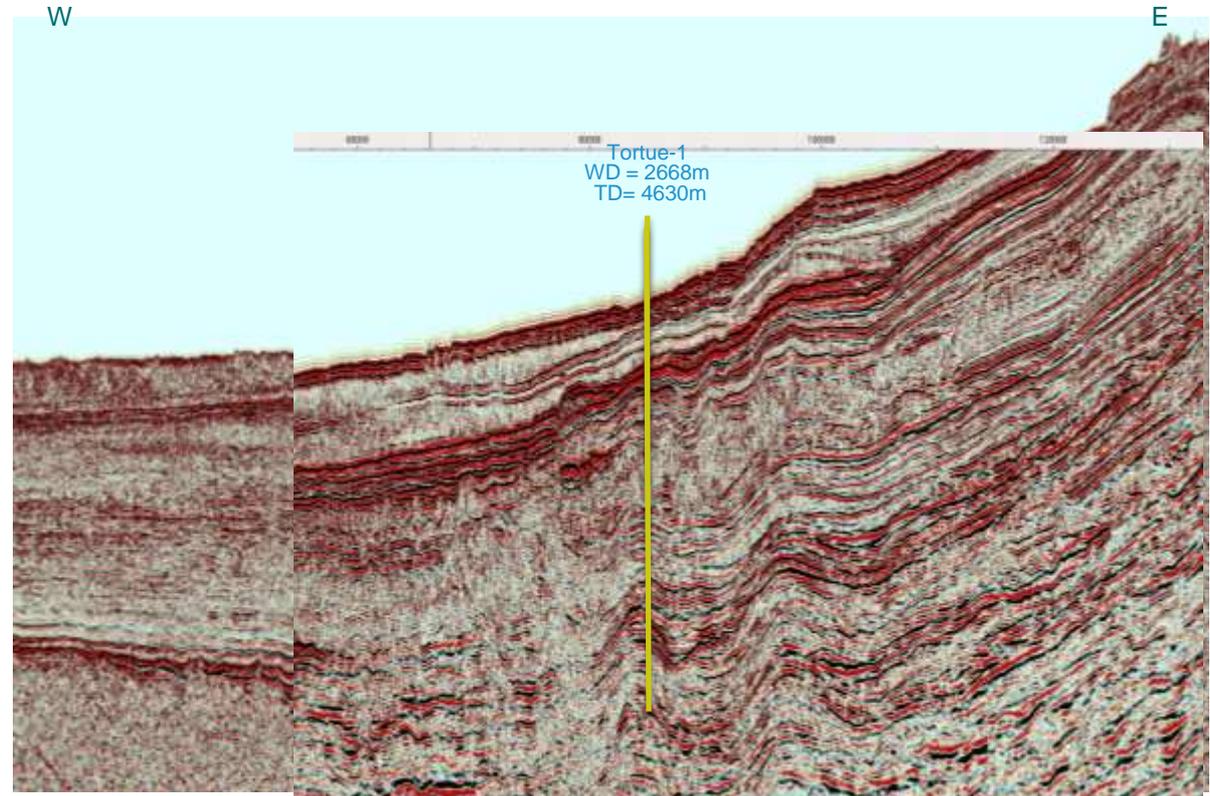
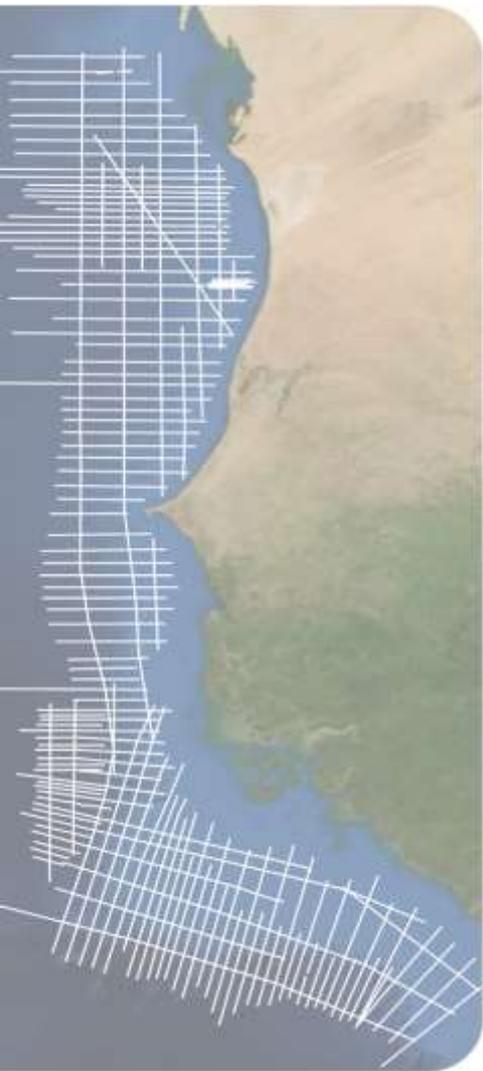
Northern Sierra Leone



Top Cretaceous
Top Aptian

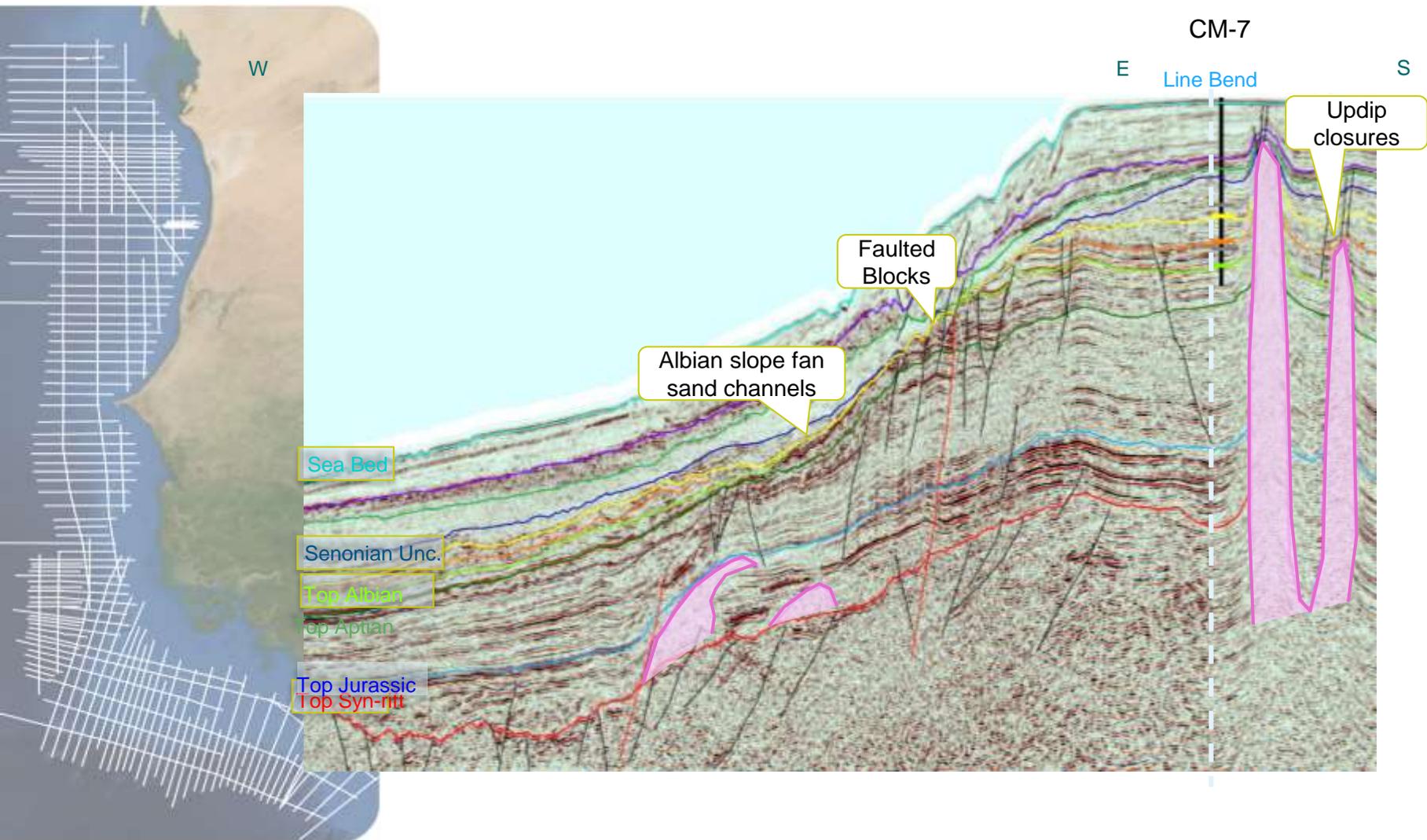
A series of Mid-Albian (syn-rift) fault terraces with some bright amplitudes within the fault blocks that relate to sand-prone sequences within the syn-rift sediments.

NWAAM – Southern Mauritanian Sub Basin

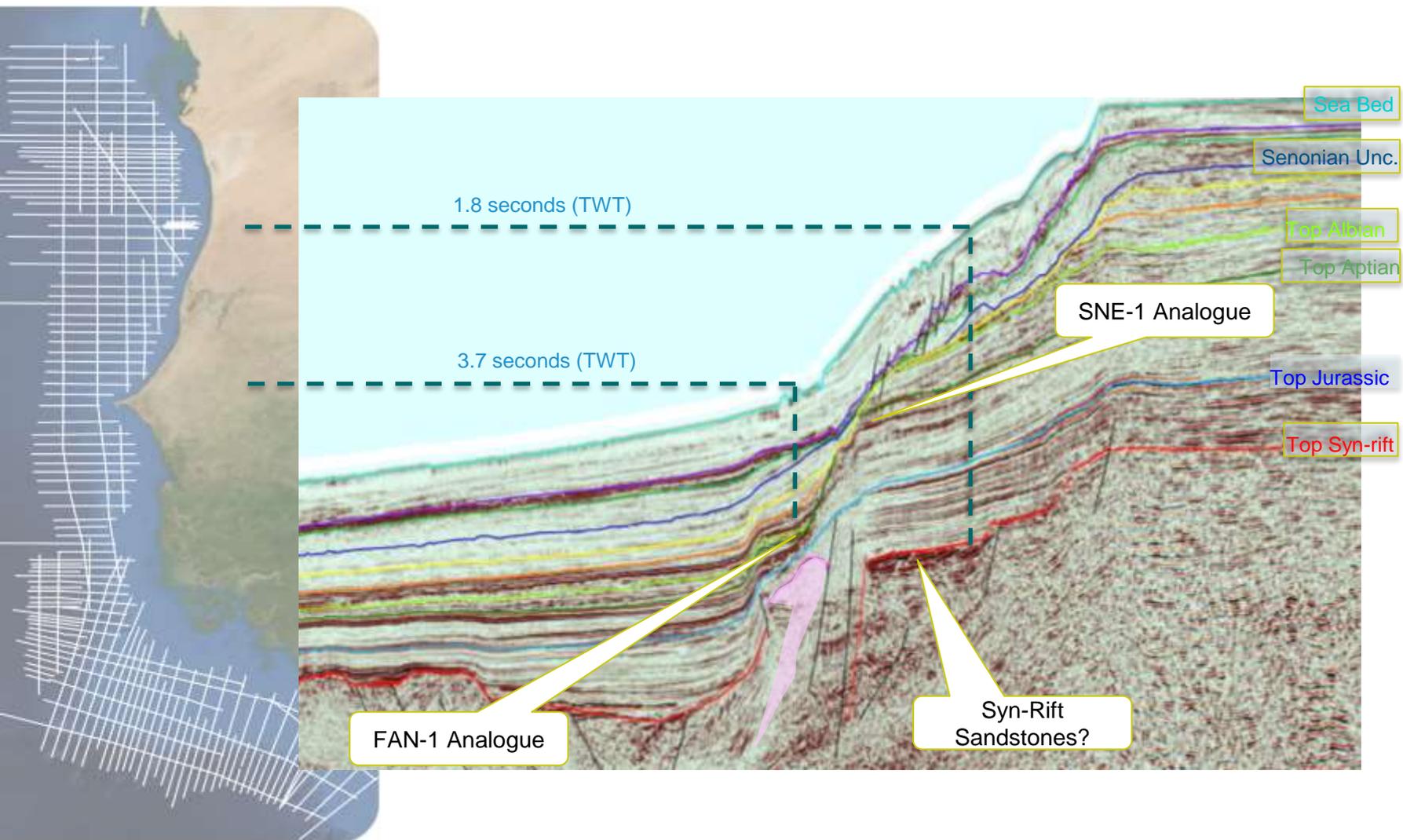


- 150m gross hydrocarbon bearing interval in the Upper Cenomanian
- 160m gross interval with 3 distinct MULTI-Darcy reservoirs in Lower Cenomanian
- Other plays deeper in the Cretaceous are also expected

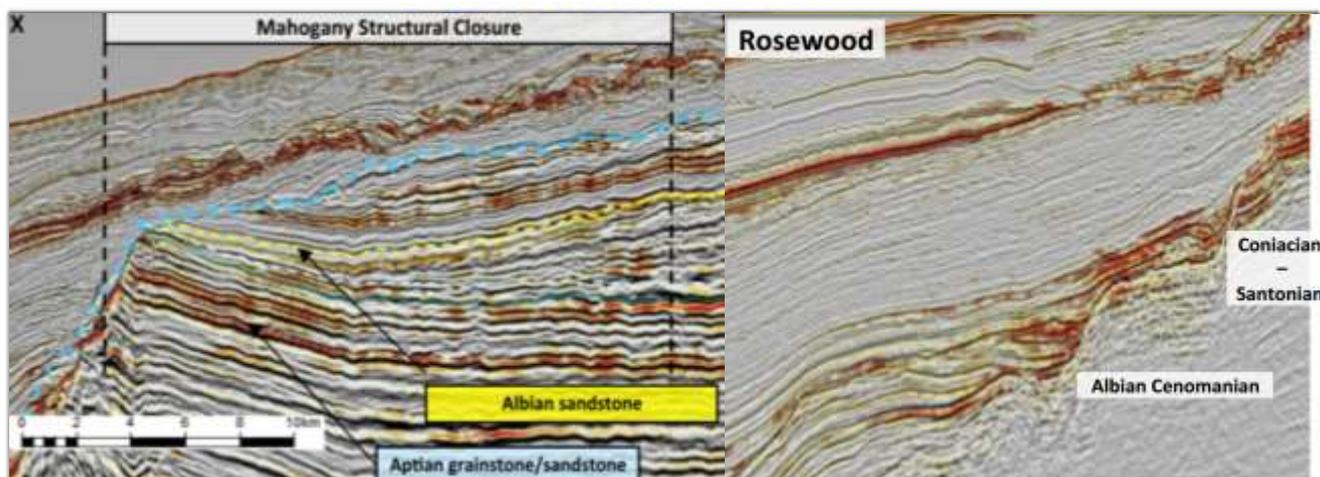
NWAAM - Casamance Sub Basin (AGC)



NWAAM - Northern Sub Basin (Offshore The Gambia)



NWAAM – The Gambia 3D



SNE-1 Analogue FAN-1 Analogue
TGS also have a multi-client 3D survey offshore The Gambia,
2,500 sq. km acquired in 2011

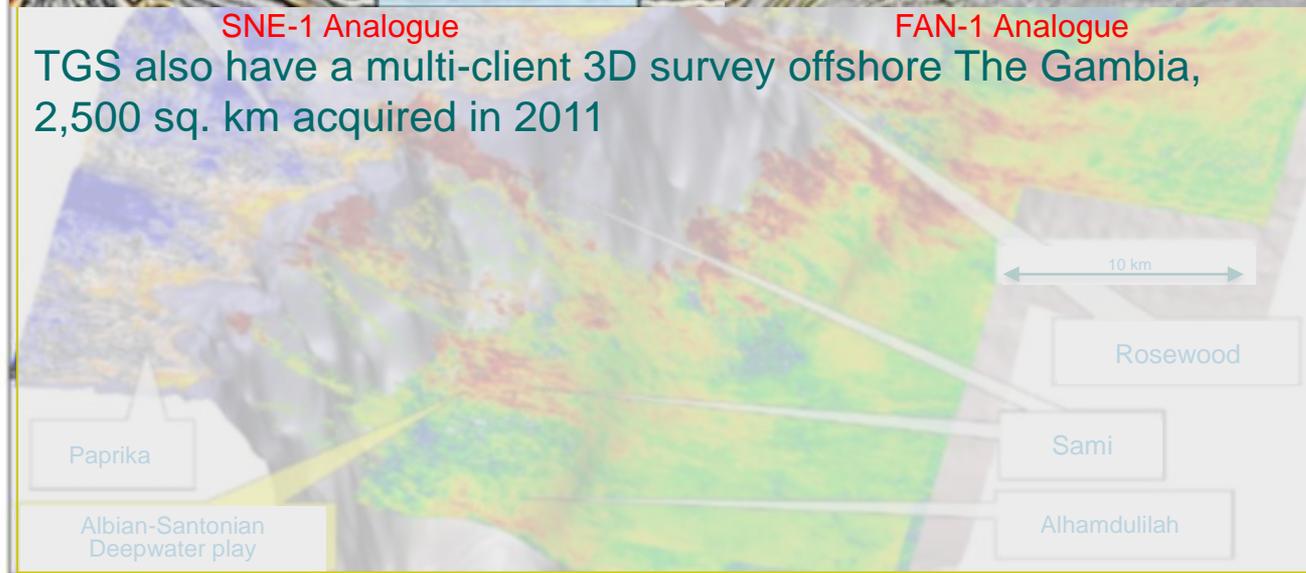


Image credit: Africa Petroleum Natural Resources Forum, April 2015



Summary - Prospectivity

There are three main petroleum systems present in the MSGBC basin:

- A **post-rift sequence**:
 - **Source** - proven Aptian / Albian / Turonian;
 - **Reservoirs** - Upper Cretaceous / Tertiary clastic rocks and Jurassic carbonates;
 - **Seals** - Upper Cretaceous/Tertiary marine shales or allochthonous salt.
- A **pre-salt sequence**:
 - **Source rocks** - Triassic lacustrine;
 - **Reservoirs** - Triassic syn-rift clastic rocks and/or Jurassic early post-rift limestones;
 - **Seals** - interbedded shales or salt.
- A **pre-rift Silurian/Devonian level**:
 - proven onshore and probably extending offshore in the shallow shelf area of Guinea Conakry.

Conclusions

Basin and Sub-basin evolution and architecture is controlled by pre-existent basement geometry, syn-rift faults, transform movements and salt tectonics.

The complex structural evolution has led to the formation of numerous **structural and stratigraphic traps** identified across the study area.

Potential DHIs such as bright spot and gas related features have been highlighted.

The numerous discoveries in the Basin **prove the existence of working petroleum systems** along the North West African Passive Margin and FAN-1 and SNE-1 prove these systems can be **commercial**.

Acknowledgments

TGS for Interpretation and modelling work:

- Dario Chisari, Peter Conn, Ian Deighton, Roel Dirx, Jennifer Halliday, Cian O'Reilly, and Erika Tiboucha.

External references:

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Thank you

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