Office des Mines Nationales et des Industries Stratégiques

Opportunities for Hydrocarbon Exploration – Morondava Offshore Basin, Madagascar

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Presentation Outline

- Madagascar general information
- Madagascar Geology Overview
- Morondava Offshore Geology
- Petroleum System
- Developments in E&P Activities
- Conclusions

Madagascar General information

Location: Africa continent, Mozambican channel and Indian Ocean, south east coast of Africa

Acreage: 587 295 sq.km

Population : 24.89 million in 2016

Language: Malagasy French (English)

Main cities : Antananarivo (Capital), Fianarantsoa Toamasina, Mahajanga, Toliary, Antsiranana

Economy: Agriculture and Tourism

Climate: tropical

Cyclonic Period: November to May

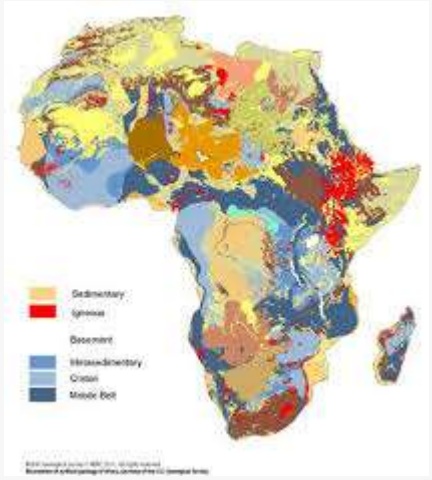
Infrastructure :

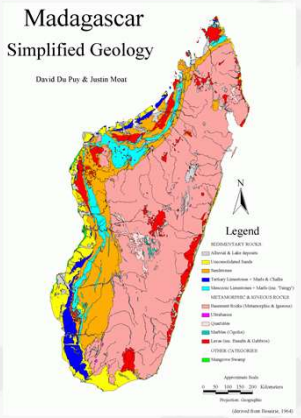
- **Main Sea port** : Toamasina, Toliary, Mahajanga, Antsiranana
- **Main Airport** : Antananarivo, Antsiranana, Toamasina, Morondava, Nosy-be, Sambava, Mahajanga, Toliary

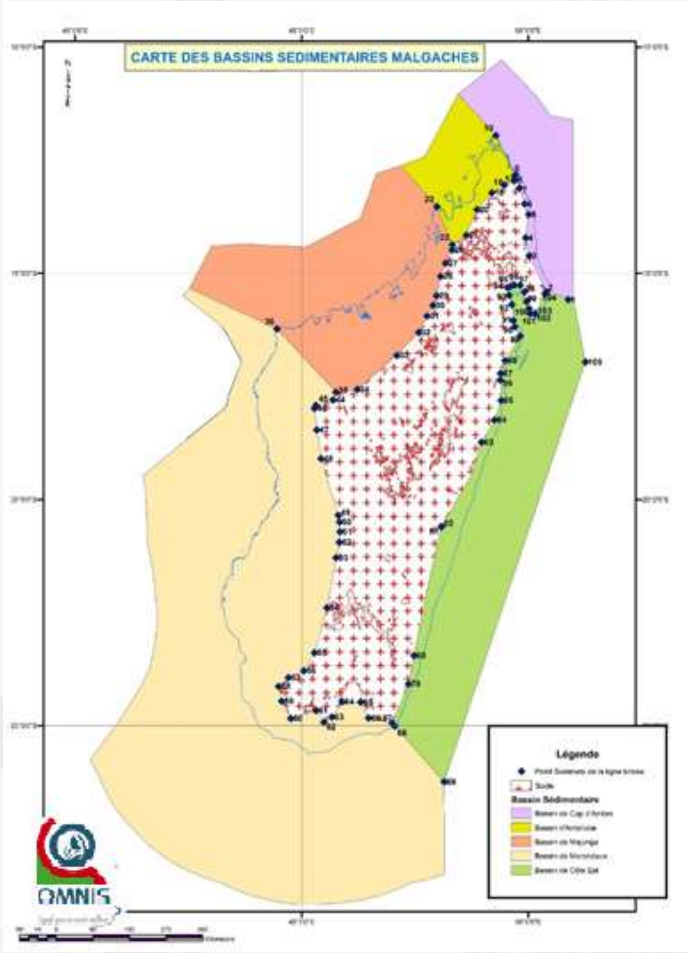
Madagascar Geology Overview

- Madagascar : 02 main geological entities:
  - ✓ Crystalline basement (older than 500 my)
  - ✓ Sediments: Carboniferous to recent

- 05 sedimentary basins : 1, 104, 900 km²



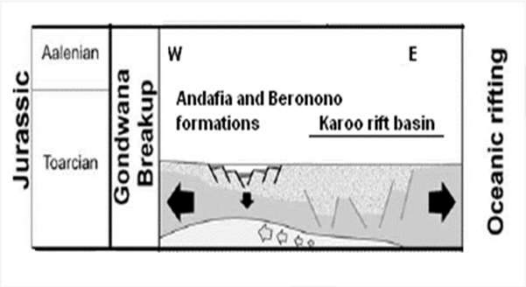


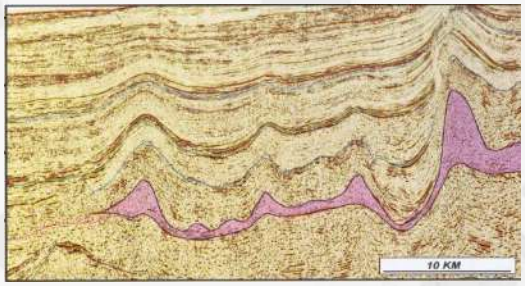


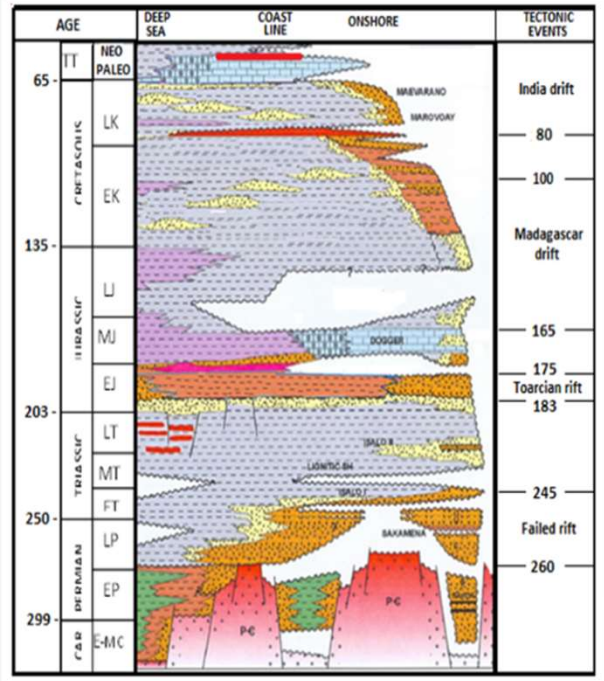
Madagascar Geology Overview (cont'd)

Tectono-Stratigraphy

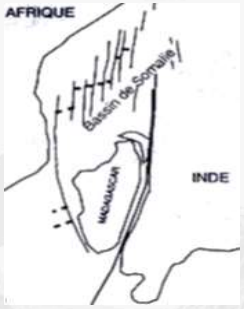
- Pre-rift sediments Late Carboniferous – Early Permian
- Permo-Triassic Failed rift sequences
- Toarcian rift related sediments
- Early Jurassic salt deposits
- Dogger Platform accretion & Passive margin series
- Middle Jurassic - Early Cretaceous drift sequences
- Late Cretaceous drift sequences- India-Madagascar
- Tertiary platform accretion







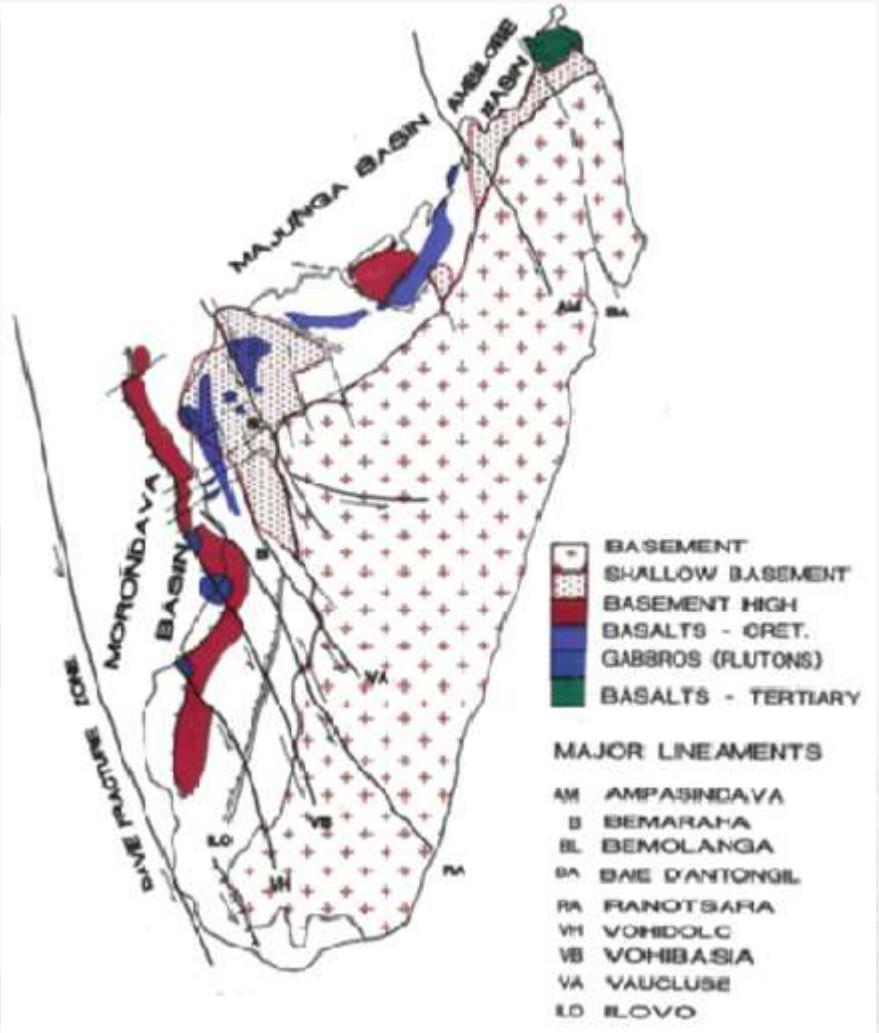
Madagascar Chronostratigraphy



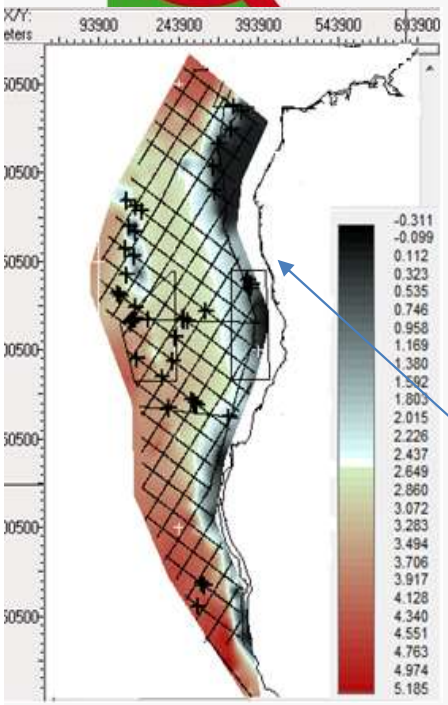
Madagascar Geology Overview (Cont'd)

Main Structural Trends

- A set of **NNE-SSW** faults parallel to the spreading axis of Somalia basin
- **NNW-SSE accident trend:** inherited from basement structure, active during Jurassic time
- A set of **sub-EW** faults or lineaments, active during the late Cretaceous time

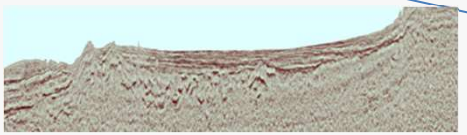


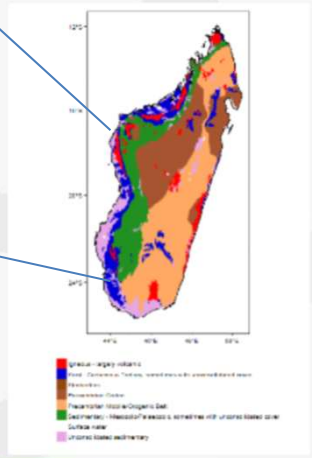
Morondava Offshore Geology



Basin Localisation and Architecture

- Western coast of Madagascar
- Acreage: 190 000km2
- Shelf : 20km width - about 200km long
- Deep depression of 40km width
- Water depth: 300 m to 3000 m
- Sediment fill : Mesozoic – recent
- Morondava basin - Conjugate of Tanzania and Mozambican coastal basins

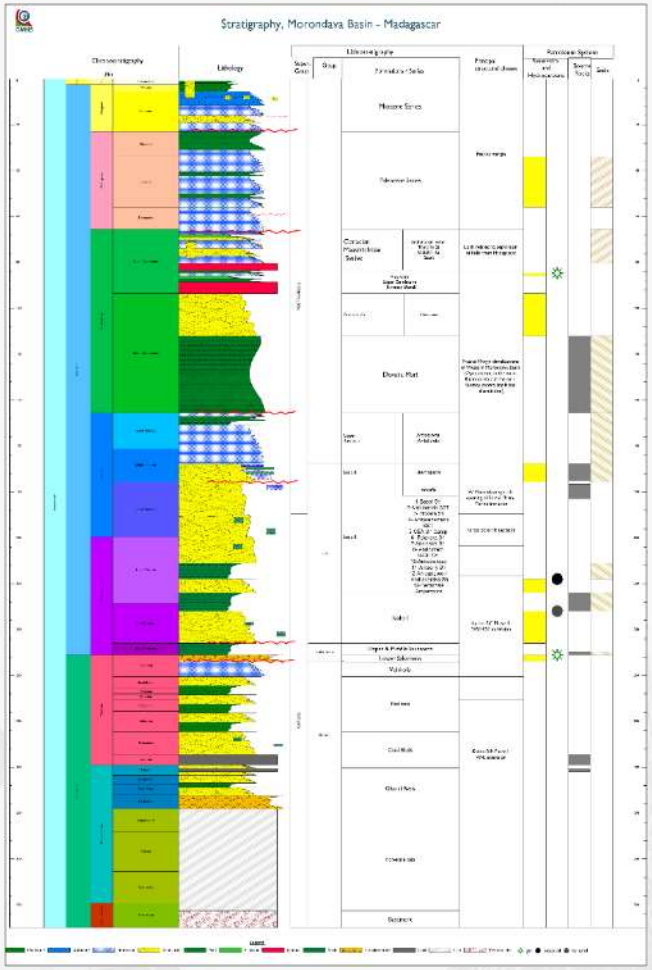




Morondava Offshore Geology (Cont'd)

Morondava Offshore Chronostratigraphy

- **Permo-Triassic** : continental facies
- **Toarcian:** marine and continental facies
- **Middle Jurassic**: carbonate to detrital deposit
- **Upper Jurassic – Lower Cretaceous**: marine sediments
- **Late Cretaceous**: near shore sandstones
- **Tertiary**: Marine coastal sand, carbonate and deep water fan deposits



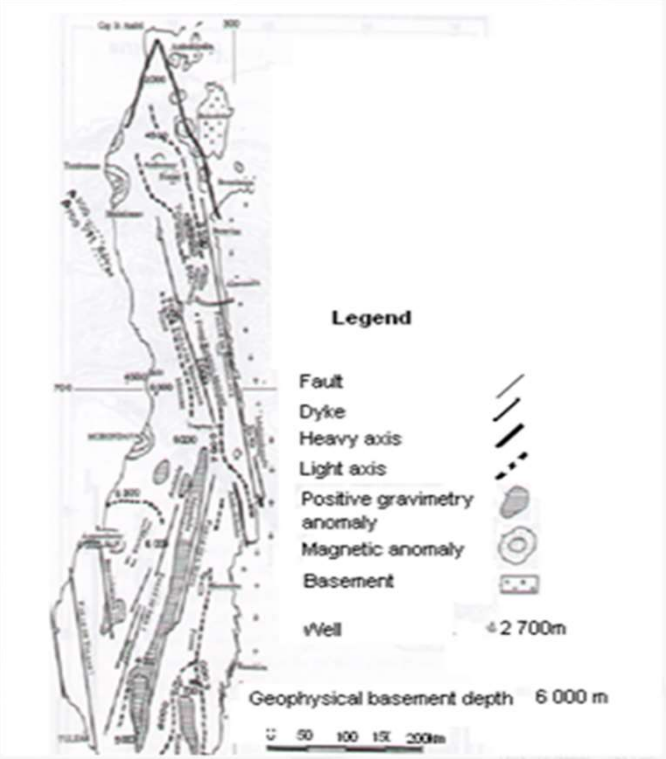
Morondava Offshore Geology

(Cont'd)

Tectonic Pattern

- **NNW-SSE:**
  - ✓ Basement lineament following the Ranotsara shear zone
  - ✓ Onset of regional strike slip fault following the Davie Fracture Zone during the drifting of Madagascar from Africa,

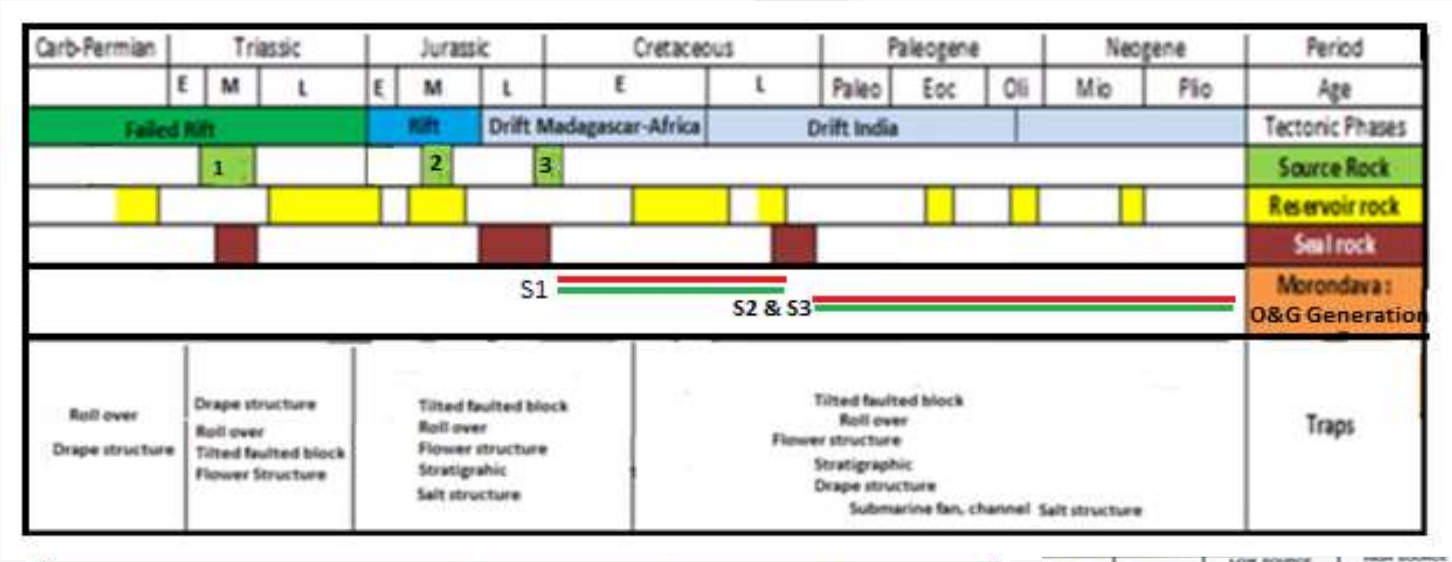
- **NNE-SSW:** Fault system
  - ✓ Following the Toarcian rift and announcing the separation of Madagascar from Africa
  - ✓ Controlling the deposition of the passive margin series and initiating the separation of India from Madagascar



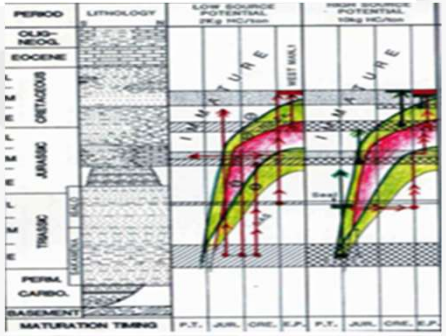
Major structures of Morondava basin

Petroleum System

Source Rocks



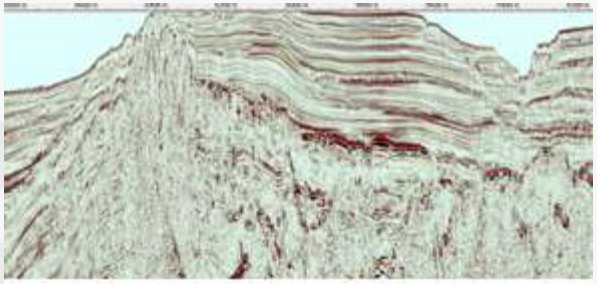
Source Rock / Sequences	TOC %	S_2 Kg HC/T	Type
S1 / Lower Trias	0.8 – 5.8	17-30.02	II & III
S2/ Middle Jurassic	1.5 - 3	150	II
S3/ Upper Jurassic-Lower Cretaceous	0.9 - 5	3.99- 67.78	II

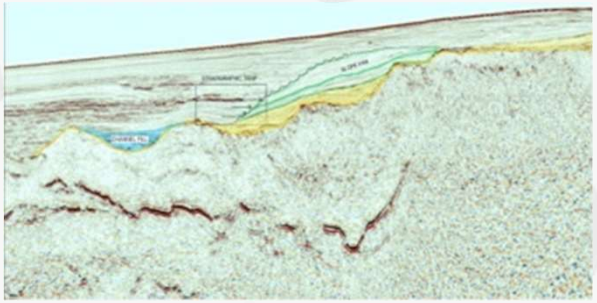


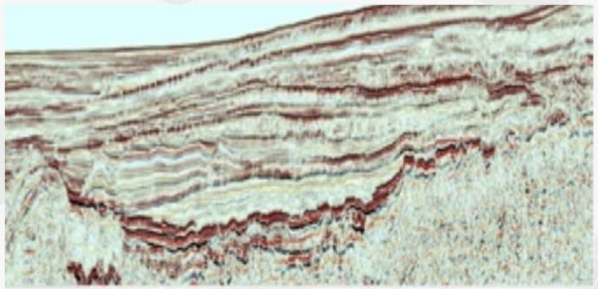
Petroleum System (Cont'd)

Reservoir Rocks Distribution

- **KAROO** : Permo-Triassic sandstone uplifted by the transpressionnal movement during drifting
- **Upper Jurassic – Lower Cretaceous** sandstones deposited by minor regression regime
- Sandstones paleovalleys fill related to basement westward tilted
- **Lower Cretaceous** Low stand and Upper Cretaceous Deep fan
- Prograding **Tertiary** sandstones



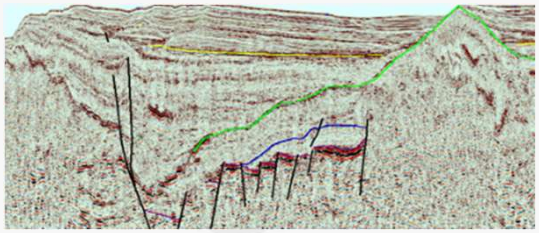


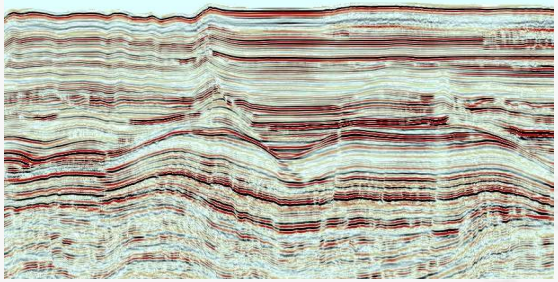


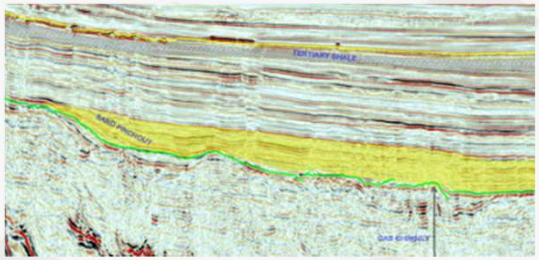
Petroleum System (Cont'd)

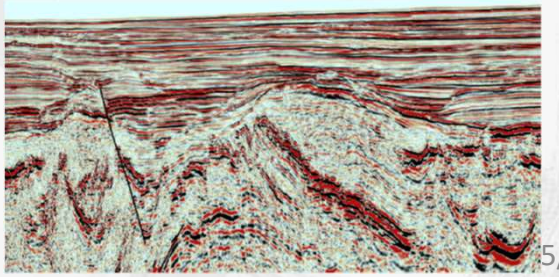
Trapping Mechanisms

- **Tilted Fault Blocks :** on the top of the Karoo group
- **Anticlines** : Compressional Anticlines due to syn-sedimentary constraints
- **Stratigraphic Traps** : Lowstand Wedges and basin floor fans
- **Channel fill**





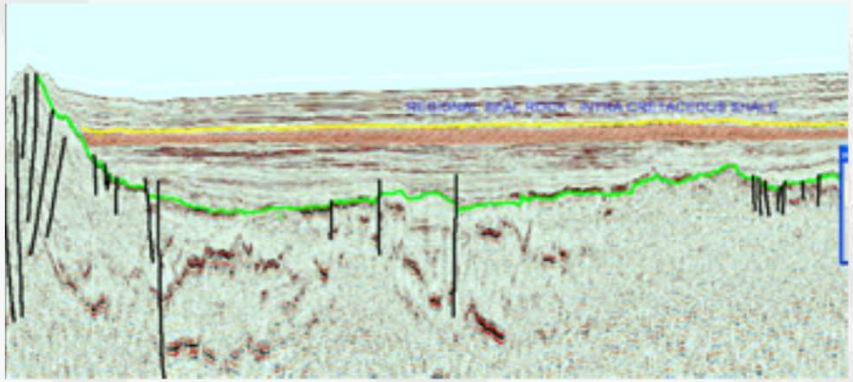


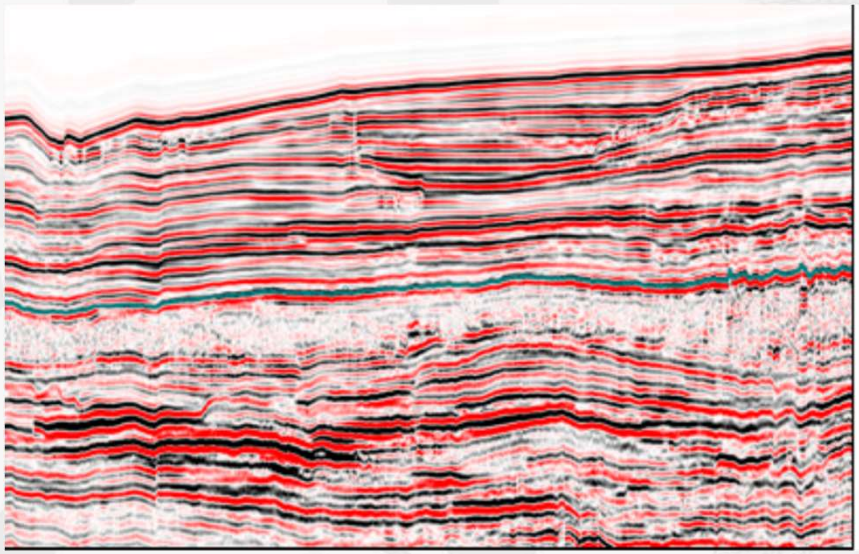


Petroleum System (Cont'd)

Seal rocks

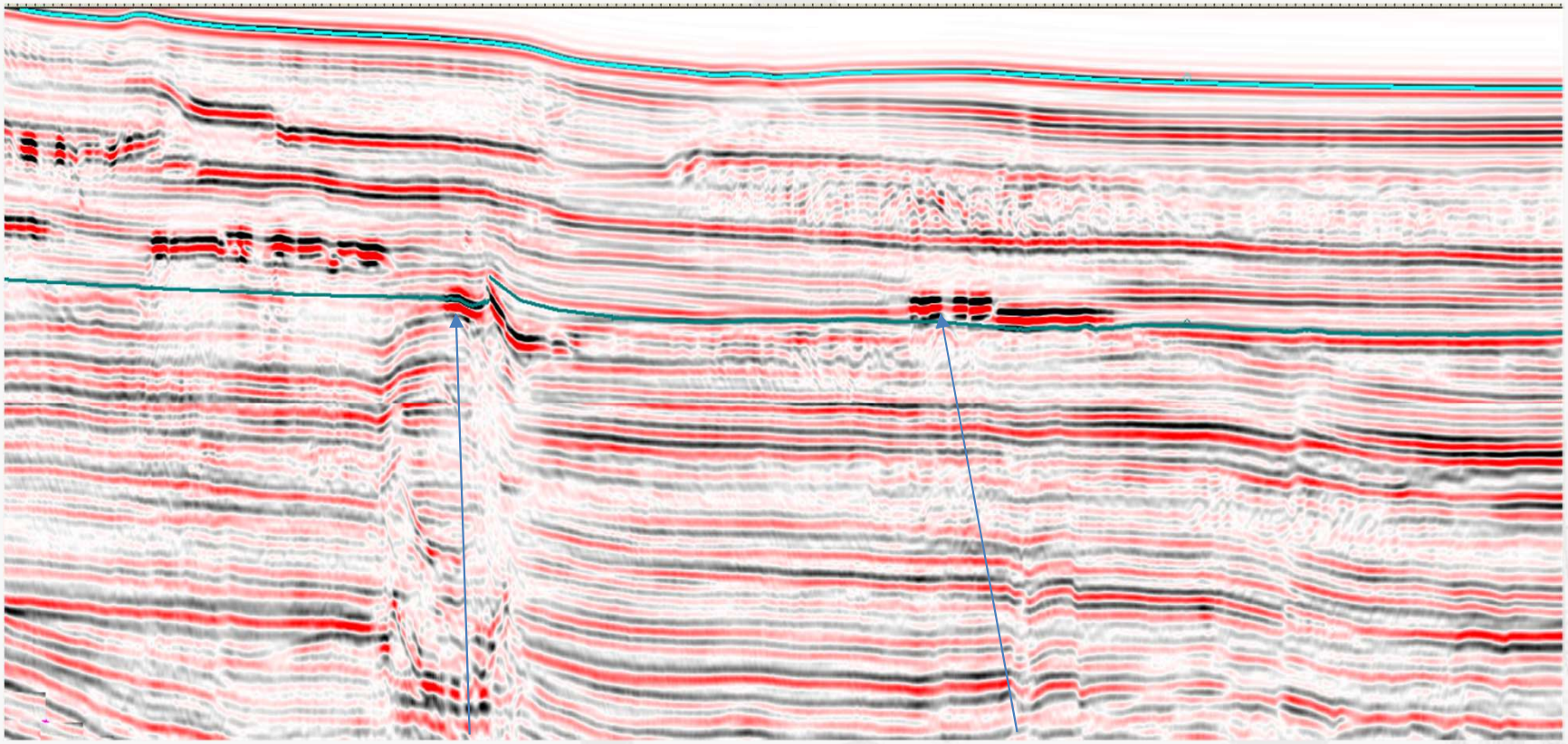
- **Shales:** Cretaceous and Tertiary
- **Andafia Shale**: Late Liassic
- **Marl** : Callovian





Petroleum System (Cont'd)

Presence of DHIs

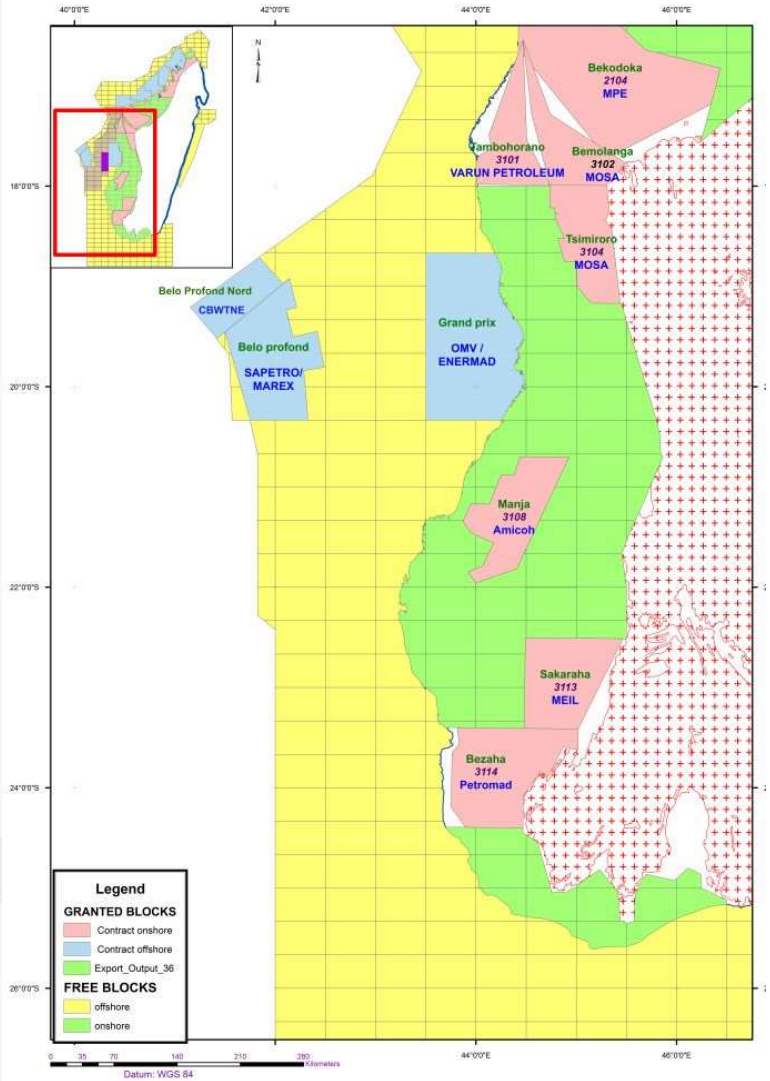


Gas Chimneys

Developments in E&P Activities

Status of Licensing

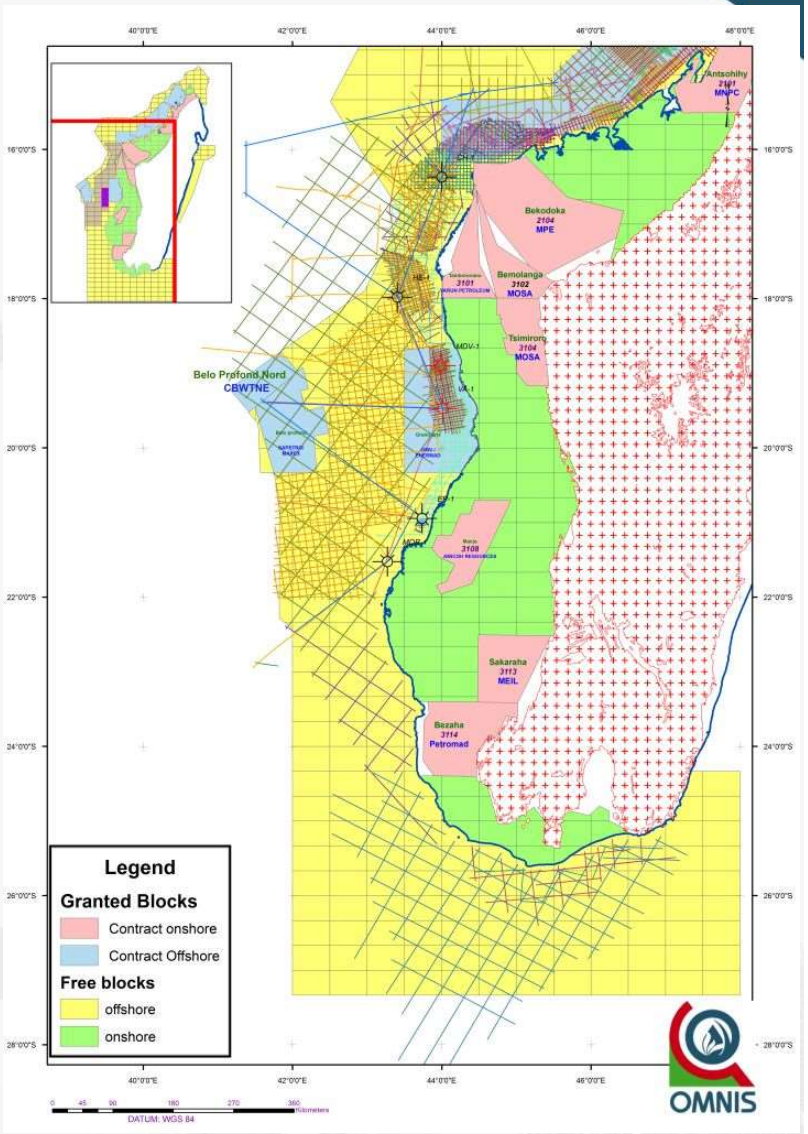
- Offshore Morondava Basin : 181 Petroleum Blocks
- 03 Active Production Sharing Contracts (PSC)
- 03 Licensed Operators :
  - ✓ SAPETRO SA - Belo Profond
  - ✓ OMV - Grand Prix Block
  - ✓ CBWTNE – Belo Profond Nord



Developments in E&P Activities (Cont'd)

Exploration Data

- Existing Geological reports and well data
- Speculative Gravity and Magnetic survey over 30 000 km
- Seismic data :
  - ✓ 42 750 km of speculative seismic 2D
  - ✓ 6 058 line km of 2D seismic
- Well data : 6 offshore wells, with hydrocarbons shows



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Developments in E&P Activities (Cont'd)

Resources potential

- Conventional Hydrocarbons
  - ✓ Geological resources: 1700 MMBBLS
- Gas Resources
  - ✓ 2.9 Tcbf (Manambolo Ouest)
  - ✓ 10 Tcbf (Sikily)
  - ✓ 20 Bcf (Toliary)
- Unconventional Hydrocarbons
  - ✓ Tsimiroro heavy oil: 1.7 MMBBLS
  - ✓ Bemolanga Tar Sand: 2 MMBBLS

Developments in E&P Activities (Cont'd)

Field development and production

- Tsimiroro heavy oil field
- Central Morondava onshore
- Good quality of the HFO:
  - ✓ Low Sulphur and Ash content, API 13°

Recent discovery

- Dry gas discovery in onshore Morondava South basin, Cretaceous
- Production test for power generations

Conclusions

- Sediments from Mesozoic to Recent over 10 km thick
- Existence of working petroleum system confirmed by well data and DHIs
- Presence of mature Source rocks expelling hydrocarbons prior to the formation of traps
- Possible extension of hydrocarbons discovery in onshore to the offshore zone
- Modern Seismic 2D Data with good quality and coverage
- Frontier basin, prospective for hydrocarbon exploration.

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