[PS]Petroleum Potential Onshore Southern Madagascar, Morandava Basin, Block 3114*

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Search and Discovery Article #10843 (2016)**
Posted March 21, 2016

*Adapted from poster presentation given at AAPG/SEG International Conference & Exhibition, Melbourne, Australia, September 13-16, 2015

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Abstract

Block 3114 is located in the southwestern Madagascar in the Morandava basin. The Madagascar potential reservoirs in this basin are Permo-Triassic in age and part of a failed rift with East Africa. Madagascar began drifting from Africa in the Lower Cretaceous and as a result has a different thermal history than East Africa. Surface seeps and vitrinite reflectance data indicate oil not gas should predominate. Sands in the Sakamena are potential reservoirs and the shales in this interval are source rocks. Recent 2D seismic data (approximately 165 km) indicate numerous structural traps.

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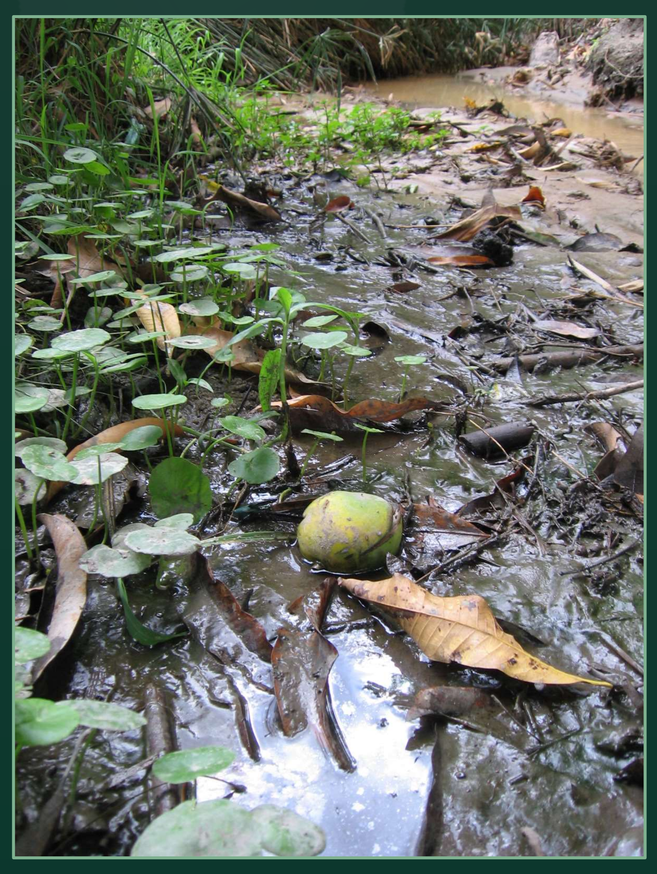
Introduction

Block 3114 is located onshore in the southwestern Madagascar in the Morondava Basin. Block 3114, also known as the Bezaha Block is large (10,600 km^2) and is underexplored. The Morondava Basin has a Permo-Triassic connection with Karoo equivalent basins in Africa. Plate tectonically, Madagascar drifted away from East Africa as a result of the breakup of Gondwana, and as a result has a different thermal history. An active petroleum system has been documented by:

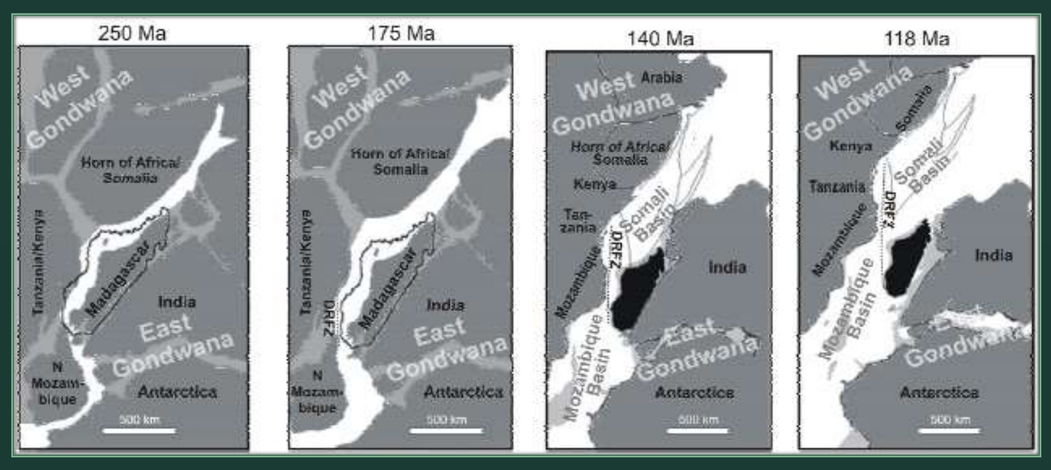
- Oil migration and generation – surface seeps, new discoveries on blocks to the north
- Reservoirs – permeability and porosity in cores, well logs, and outcrop
- Source rocks – with Ro values in the oil window



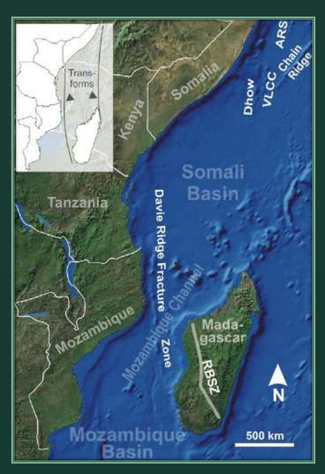
The USGS concluded in a 2012 assessment of the Morondava Basin that there is a mean undiscovered conventional oil resource of 10.75 bbl and a mean undiscovered gas resource of 167 tcf with 1,076 mmb of natural gas liquids. Lack of commercial production is attributed to the small number of wells drilled relative to the size of the basin. Most wells were drilled pre-1974 and relied on older 2D, legacy, seismic data which is low quality. MHA has identified one drill ready prospect with a geologic risked prospective oil resource best estimate of 38.9 mmb of oil.

Regional Setting

Plate Tectonics



Geiger, 2004



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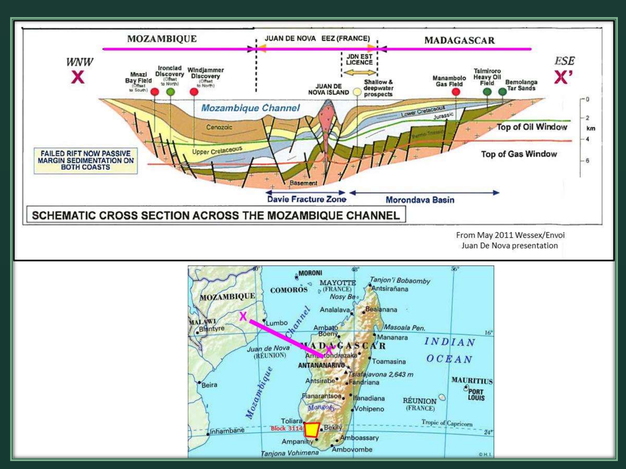
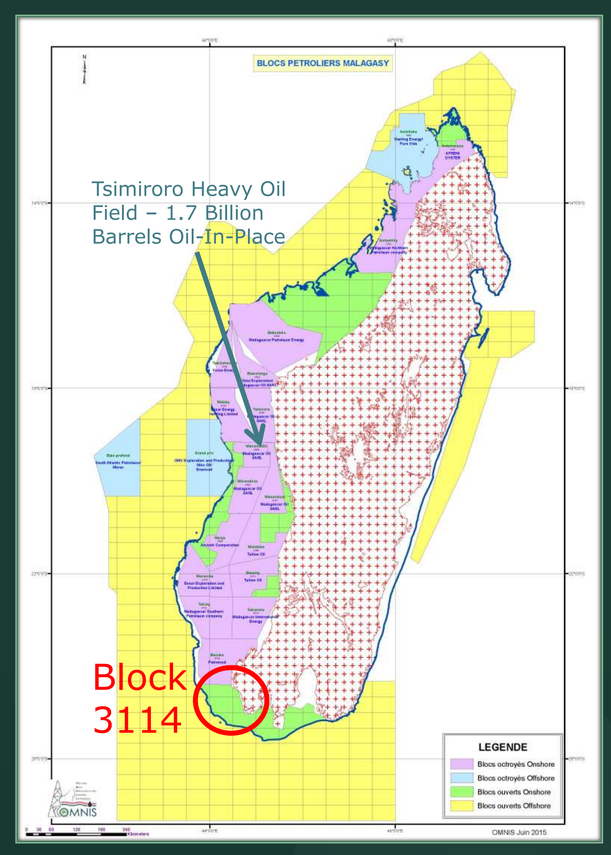
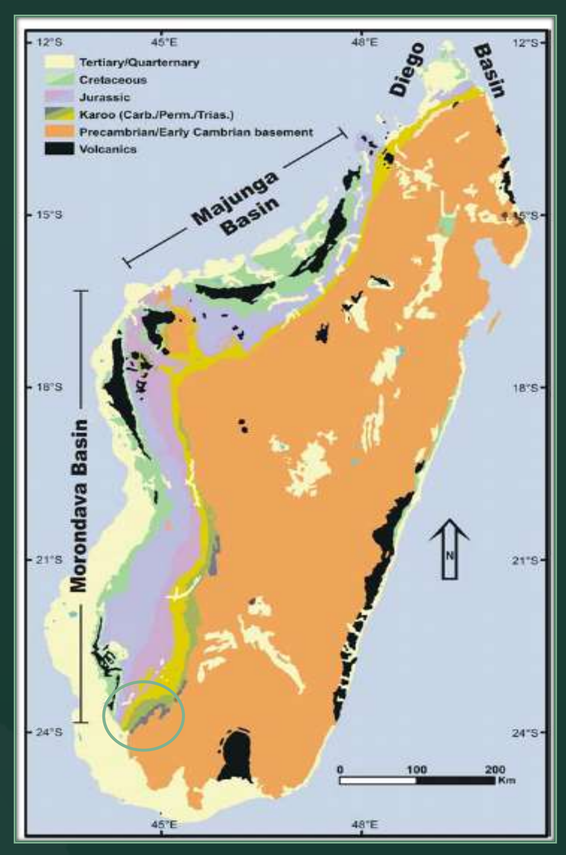




Madagascar Basins

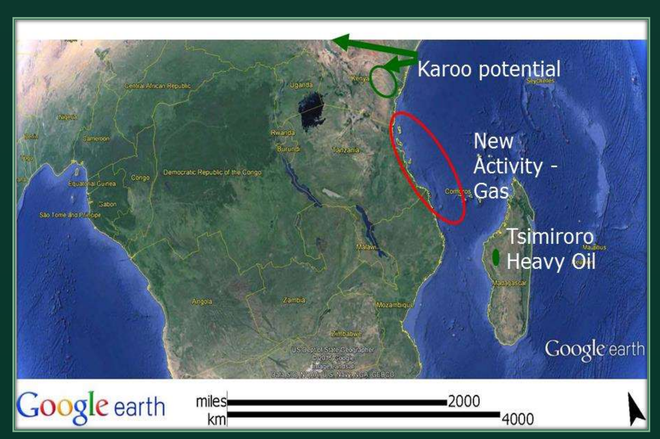


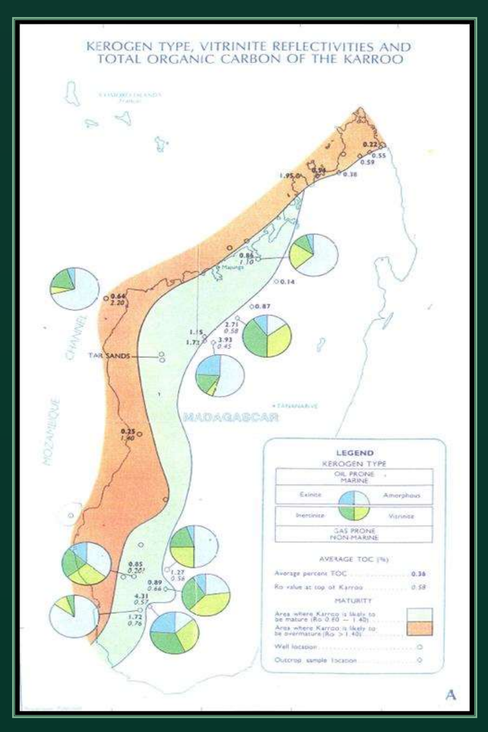
Geiger, 2004

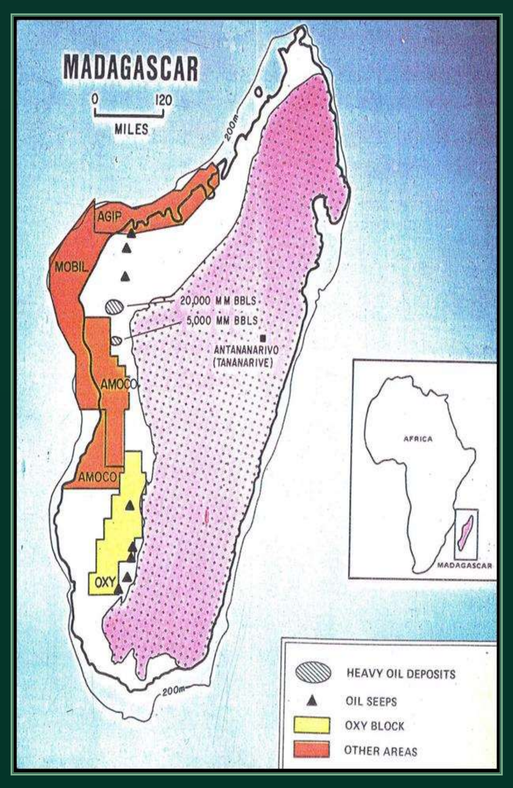
- Break up of Gonwana beginning in the Middle to End of Jurassic through Early Cretaceous
- Madagascar was part of a failed rift - drifted away along the Davies Fracture Zone

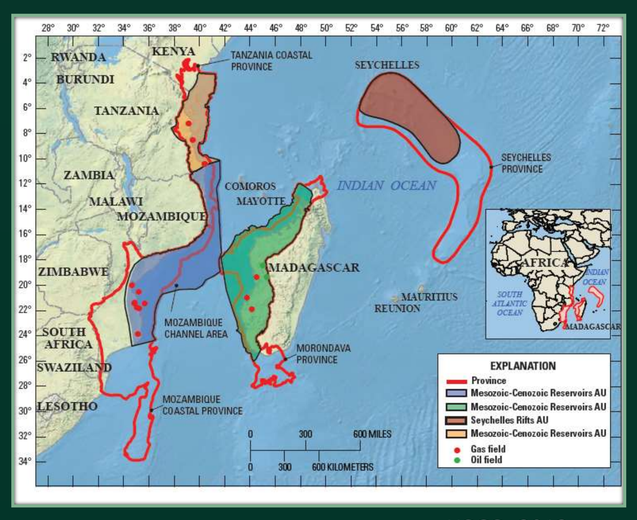
- Bezaha Block 3114 located Morondava Basin (10,160 Km^2)
- Surface outcrops range from Karoo (Permo-Triassic) through Tertiary
- Target reservoirs are Permo-Triassic Karoo Sediments

Geochemistry







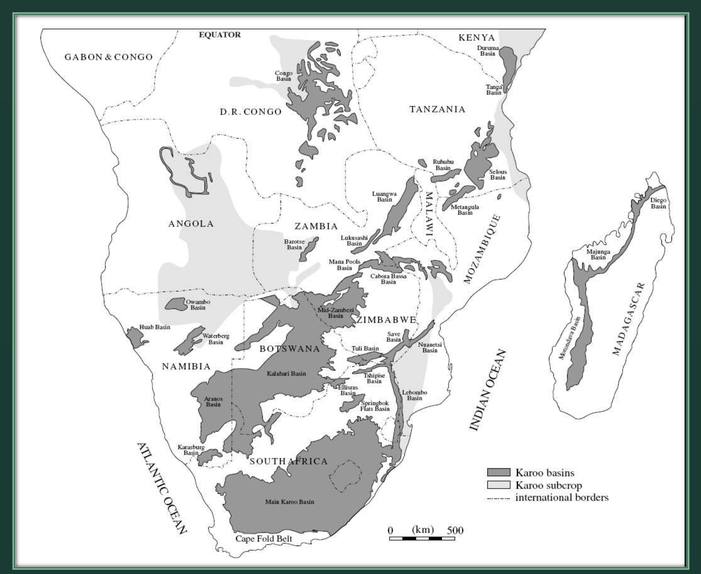


USGS, 2012

- Different thermal history than east Africa due to Madagascar drifting away from the continent
- Tsimiroro heavy oil field produces from younger age rocks that have been biodegraded
- Karoo known source rock in East Africa (Jarvie, 2011)
- Numerous shows of oil and gas documented from previous operators
- Anticipate oil, R_o values 0.76 and Block 3114 is in an area where Karoo is expected to be mature (oil) and not overmature (gas)
- 2012 USGS assessment of Morondava Basin – 10,750 MMBO, 167 TCF, and 1,076 MMBNGL - mean undiscovered conventional resource
- Compositional modeling from remote sensing indicates potential for detection of surface microseeps

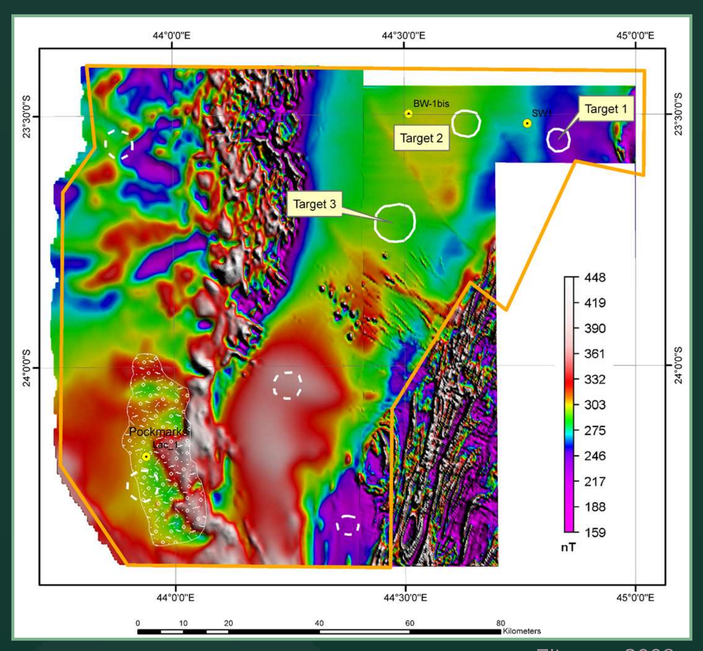
Geology

Karoo Basins

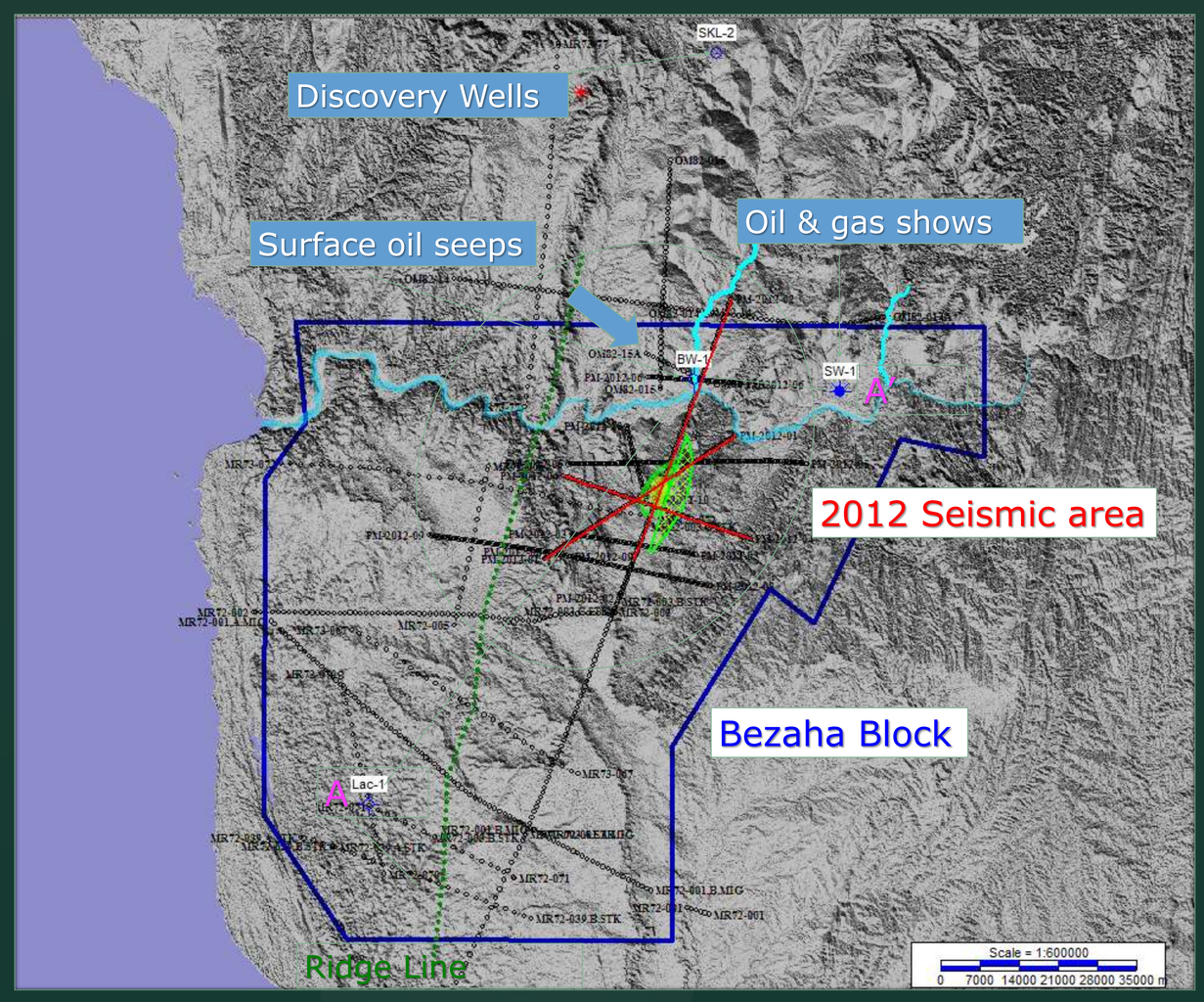


Catuneanu, 2005

Magnetic Data

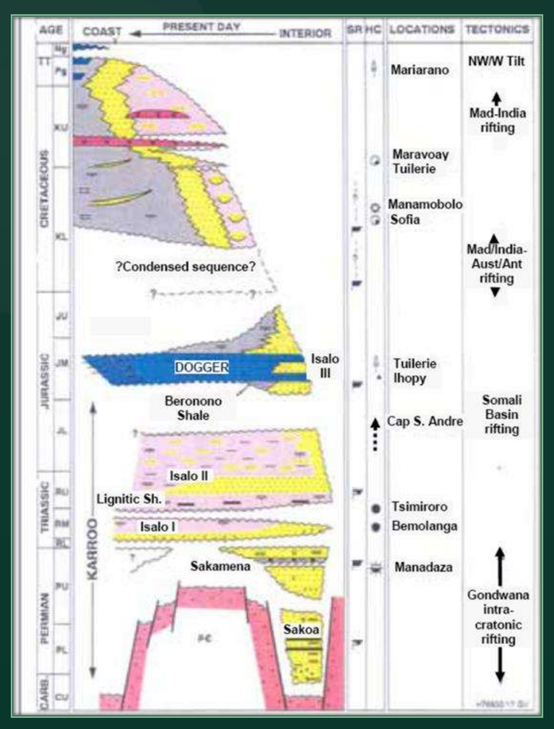


Zitcom, 2008



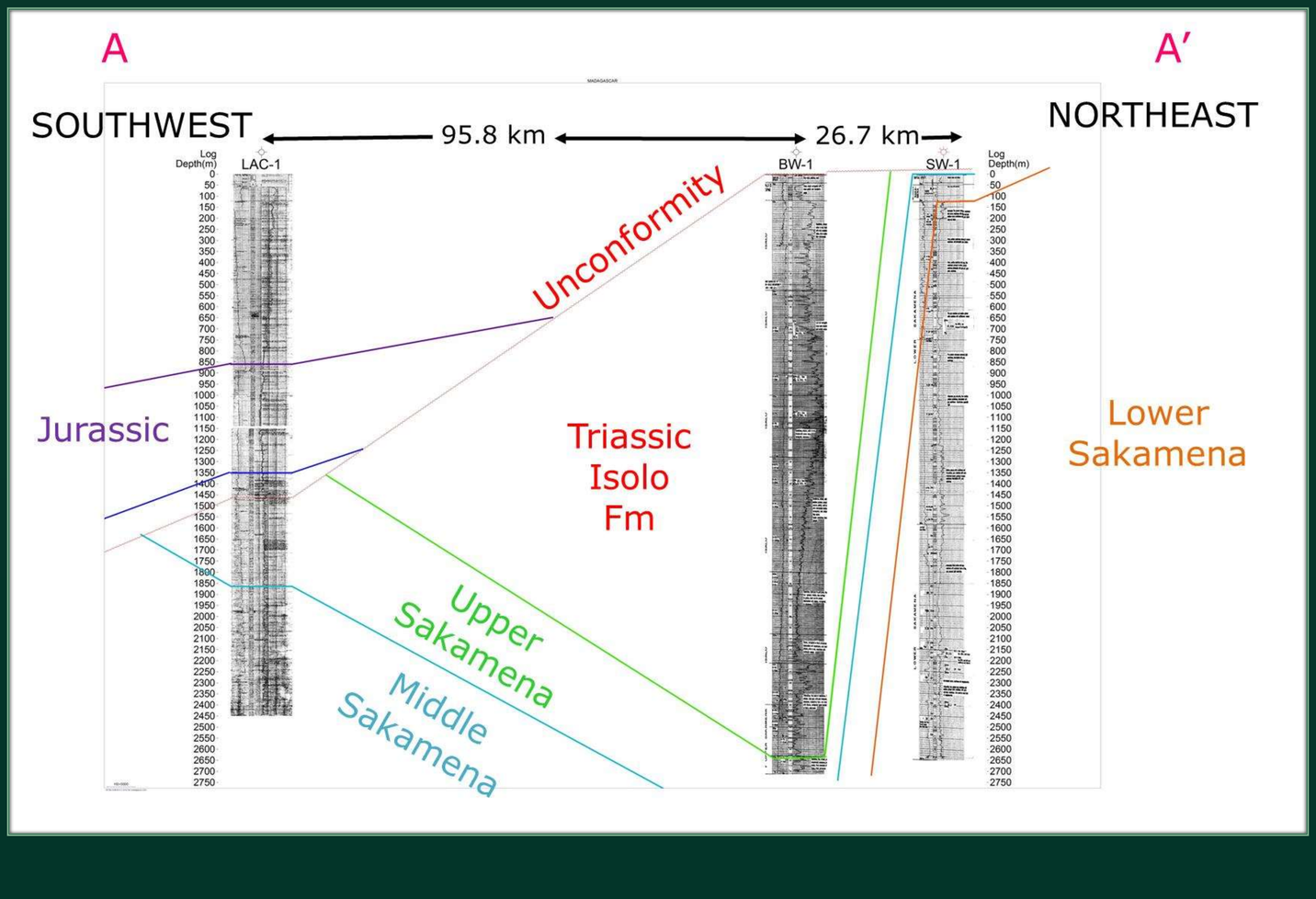
Block Base Map

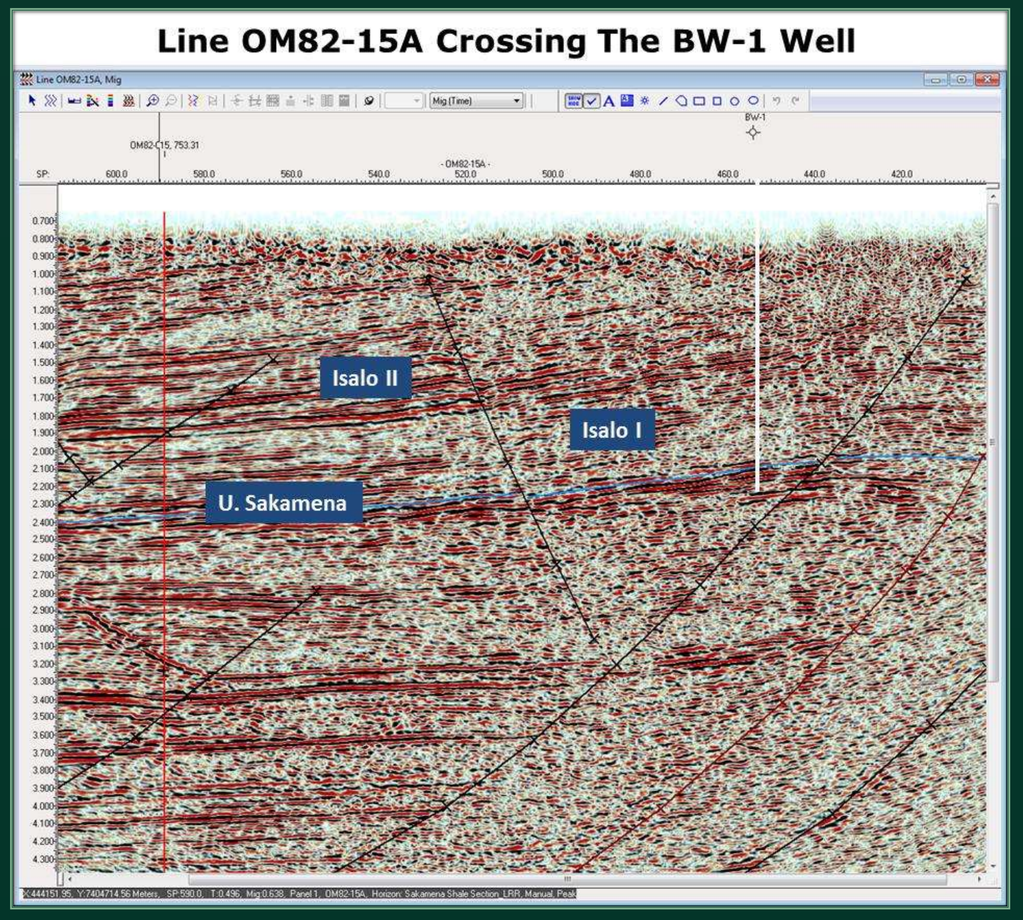
Generalized Stratigraphic Section



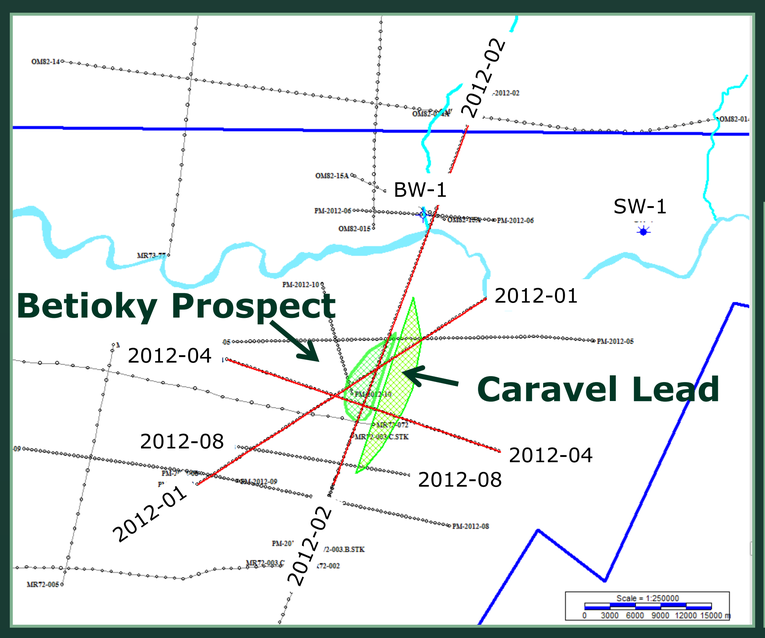
Modified from OMNIS

- Morondava Basin in Permo-Triassic is part of the African Karoo basins – 2 Discovery wells on blocks to the north
- Bezaha Block is 10,160 Km^2 with only three penetrations:
  - LAC-1 drilled in 1974 by Chevron
  - BW-1bis drilled in 1951
  - SW-1 drilled in 1952
- Structural Cross – Section through three penetrations indicates Triassic Unconformity along with oil and gas show in SW-1 well
- Primary reservoirs are Upper, Middle and Lower Sakamena
- Porous and permeable sandstones documented
- Original prospect areas defined by 2008 aeromagnetic survey
- Legacy 2D data poor quality





Seismic

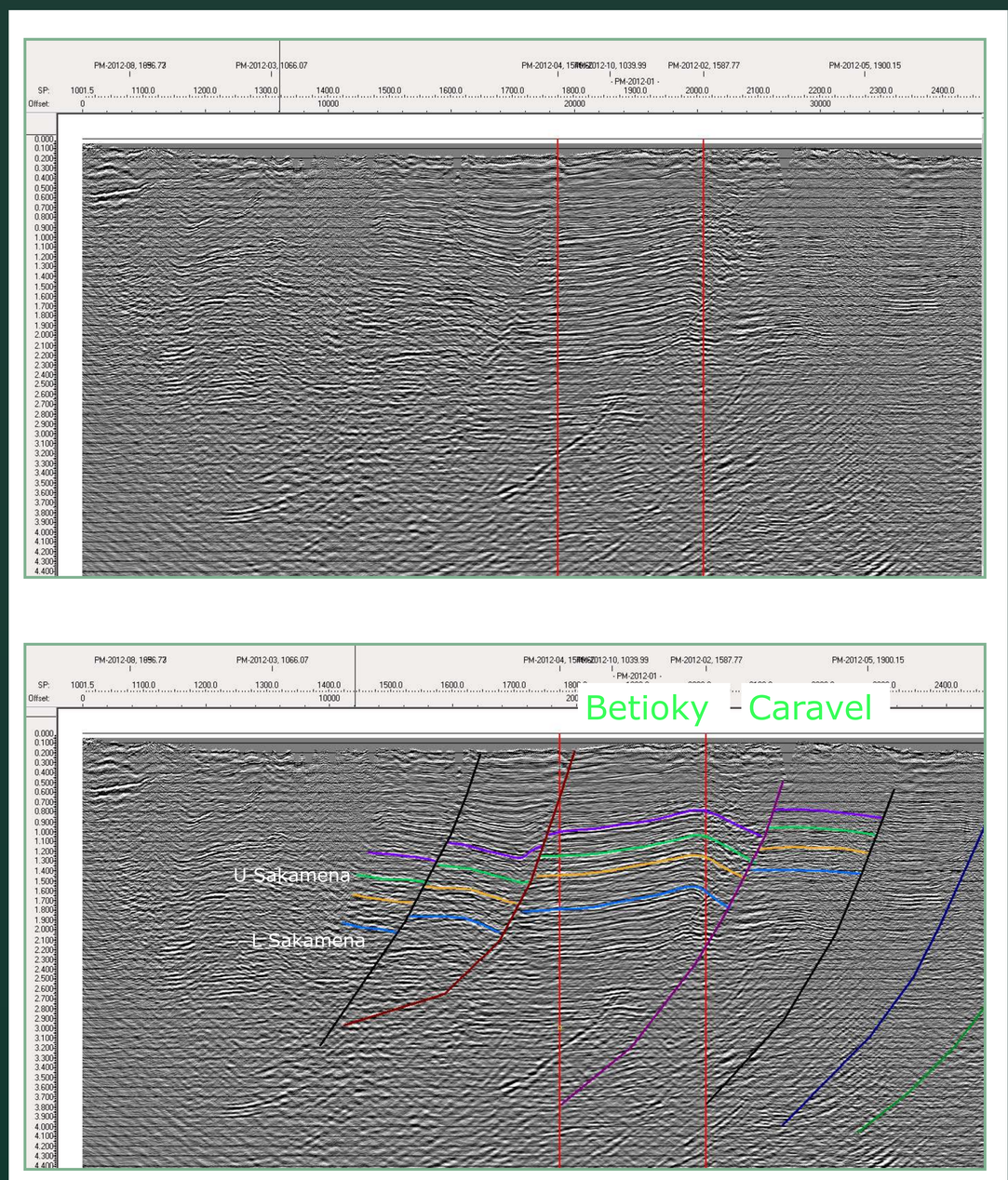


Prospective Oil Resource Assessment

Prospect	Type	Total Risked Oil Resources (millions of barrels)		
		Low	Best	High
Betioky Prospect	**Anticlinal**	**10.5**	**38.9**	**108.6**
	Area (acres)	3,000	6,000	13,000
	Thickness (feet)	1	205	397
Caravel Prospect	**Fault Trap**	**3.8**	**16.3**	**51.4**
	Area (acres)	1,000	6,000	20,000
	Thickness (feet)	1	205	397
TOTAL		**14.3**	**55.2**	**160.0**

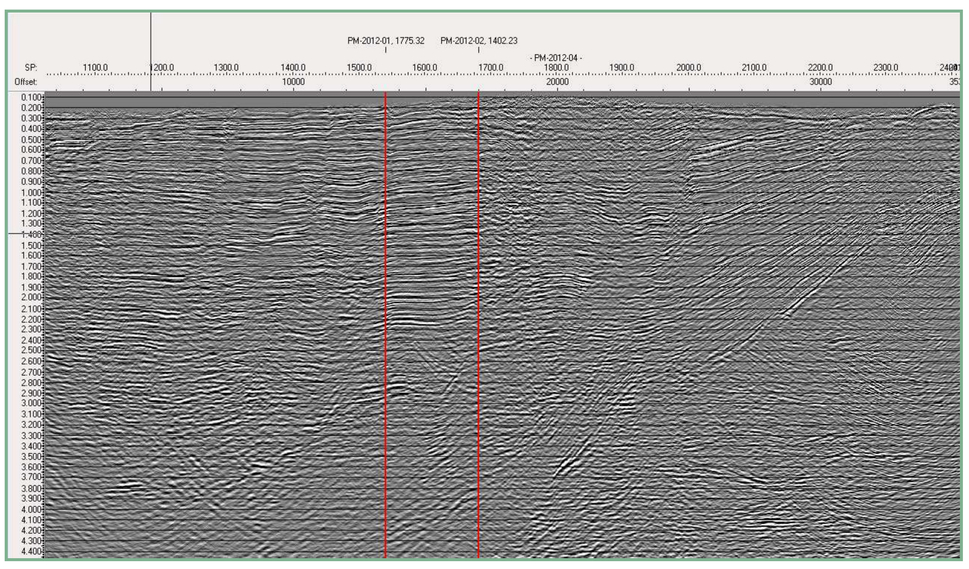
- Five 2-D seismic lines totaling 165 km acquired and processed
- Better quality data than legacy data
- Preliminary 2013 interpretation reveals a higher degree of faulting
- Several fault blocks comprise favorable geometries for trapping petroleum
- Mapping validates prospect area – Betioky Prospect - 4 way closure on fault block
- Caravel lead identified – tilted fault block
- Multiple other leads identified on the block

Line 2012-01



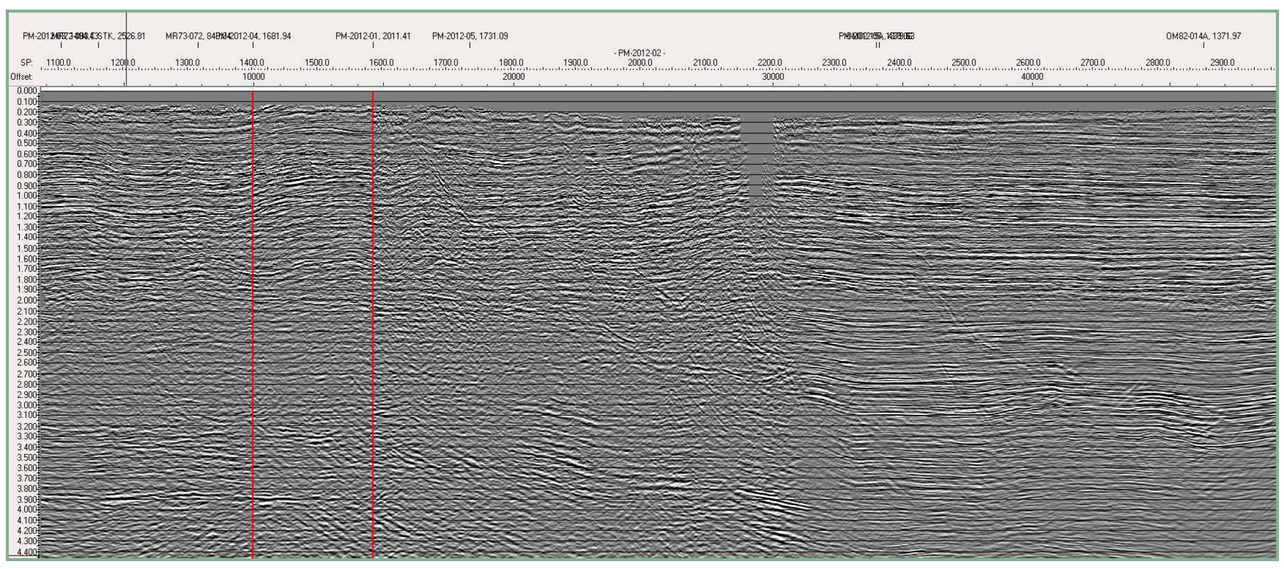
43 km

Line 2012-04



37 km

Line 2012-02



50 km

Conclusions

Block 3114 is a large onshore concession which is under explored

- **Petroleum system** identified
- **Reservoirs** in Upper, Middle and Lower Sakamena (Karoo) confirmed by porosity and permeability in core and logs
- Permo-Triassic **source rock** confirmed
- Oil **migration** and **generation** documented from numerous seeps and recent discoveries to the north
- 2012 seismic data provided better resolution over legacy data
- Increased faulting and structures interpreted on newer seismic
- Drill ready prospects