



decisions with confidence

Exploration Potential of the Rakhine Basin/Bengal Fan, Myanmar

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Regional Understanding

- Get yourself a “hot air balloon” view
- Understanding the big picture is a critical first step in any oil and gas exploration venture
- Getting the regional perspective will allow you to have your block integrated into the regional understanding
- Getting the regional knowledge will allow you to stand on the shoulders of those who went before you
- Not releasing open file exploration data in Myanmar has greatly restricted exploration in the past by not allowing the development of the regional view



Country Overview

Myanmar is one of the oldest oil producing countries in the world with onshore oil production dating back to the thirteenth century.

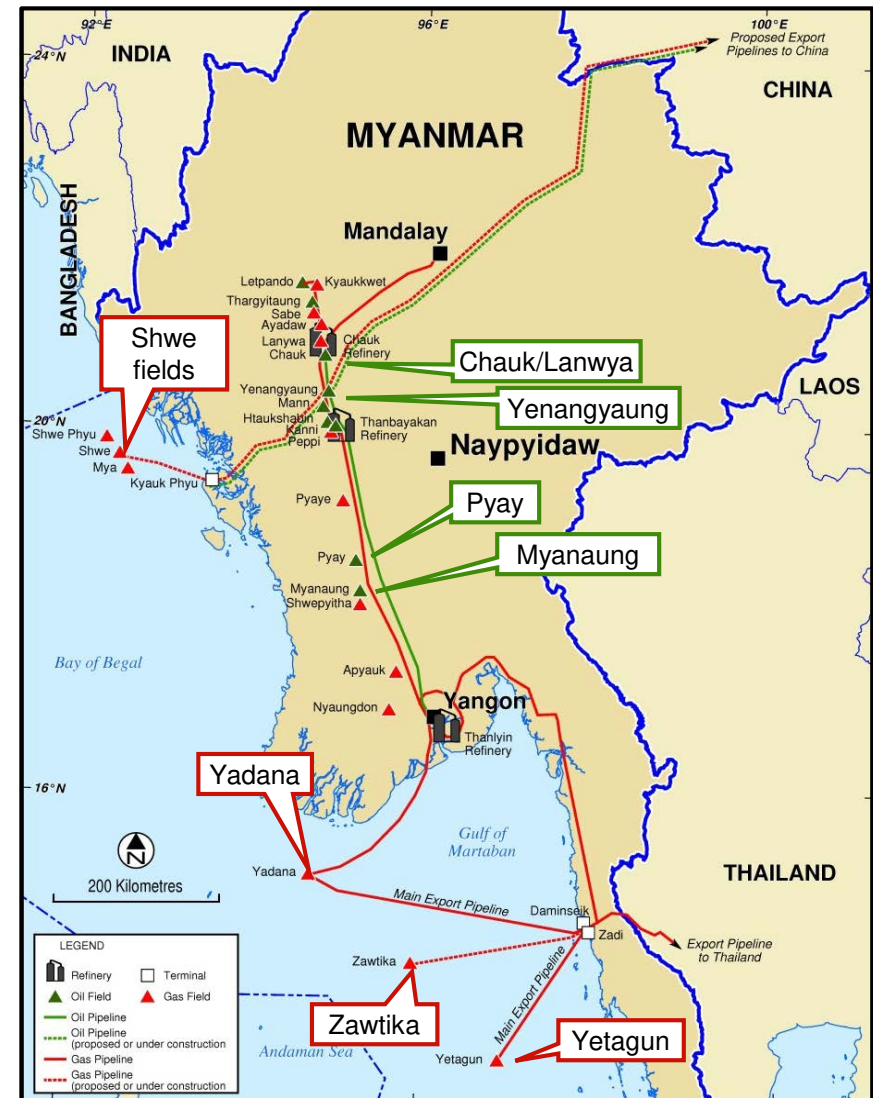
Although a large number of oil fields have been discovered most are small with the bulk of production coming from just five fields:

- Yenangyaung
- Chauk/Lanywa
- Myanaung
- Pyay (Prome)
- Mann

Offshore gas has been discovered in commercial quantities in:

- Yadana
- Yetagun
- Zawtika
- Shwe gas fields

Nevertheless, significant oil and gas potential still remain as Myanmar is considered under-explored by industry standards.



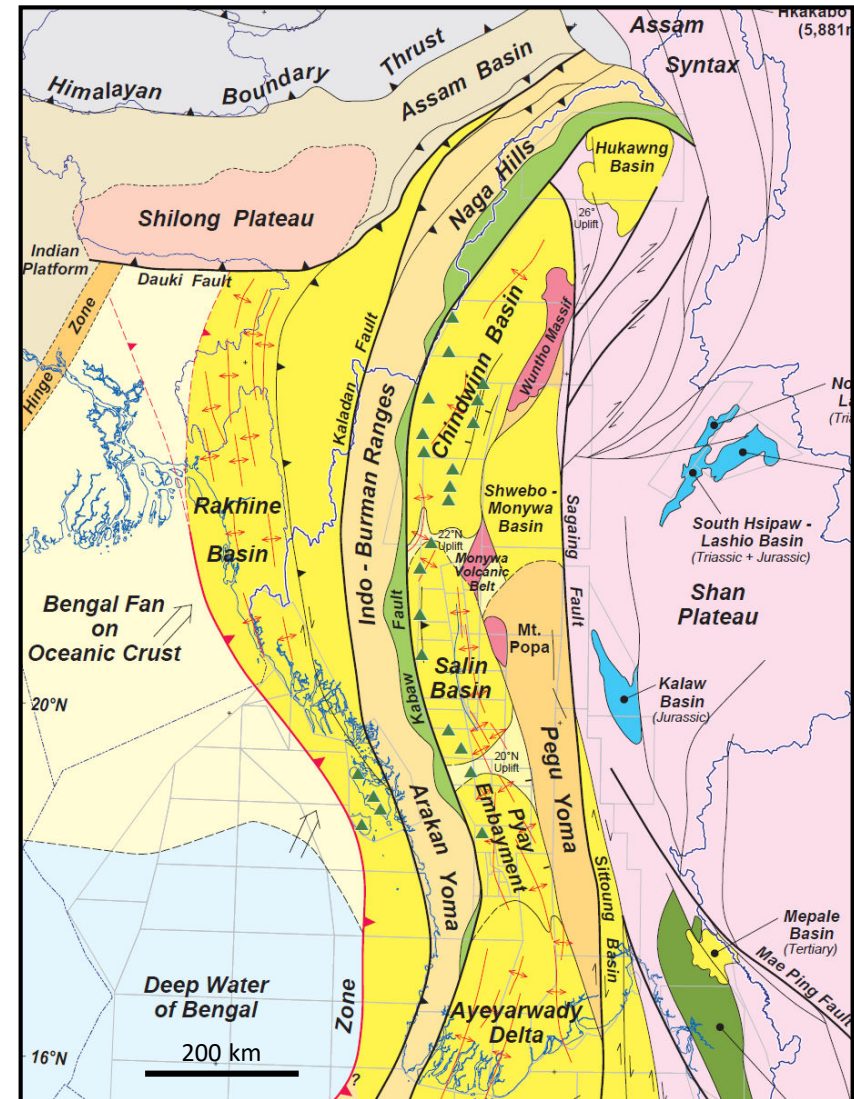
Myanmar offshore basins: strongly gas-prone.

- **Water Depths across Rakhine Basin/Bengal fan**
 - Majority of basin in water depths < 2,000 m
 - Up to 3,000 m increasing to the west and south



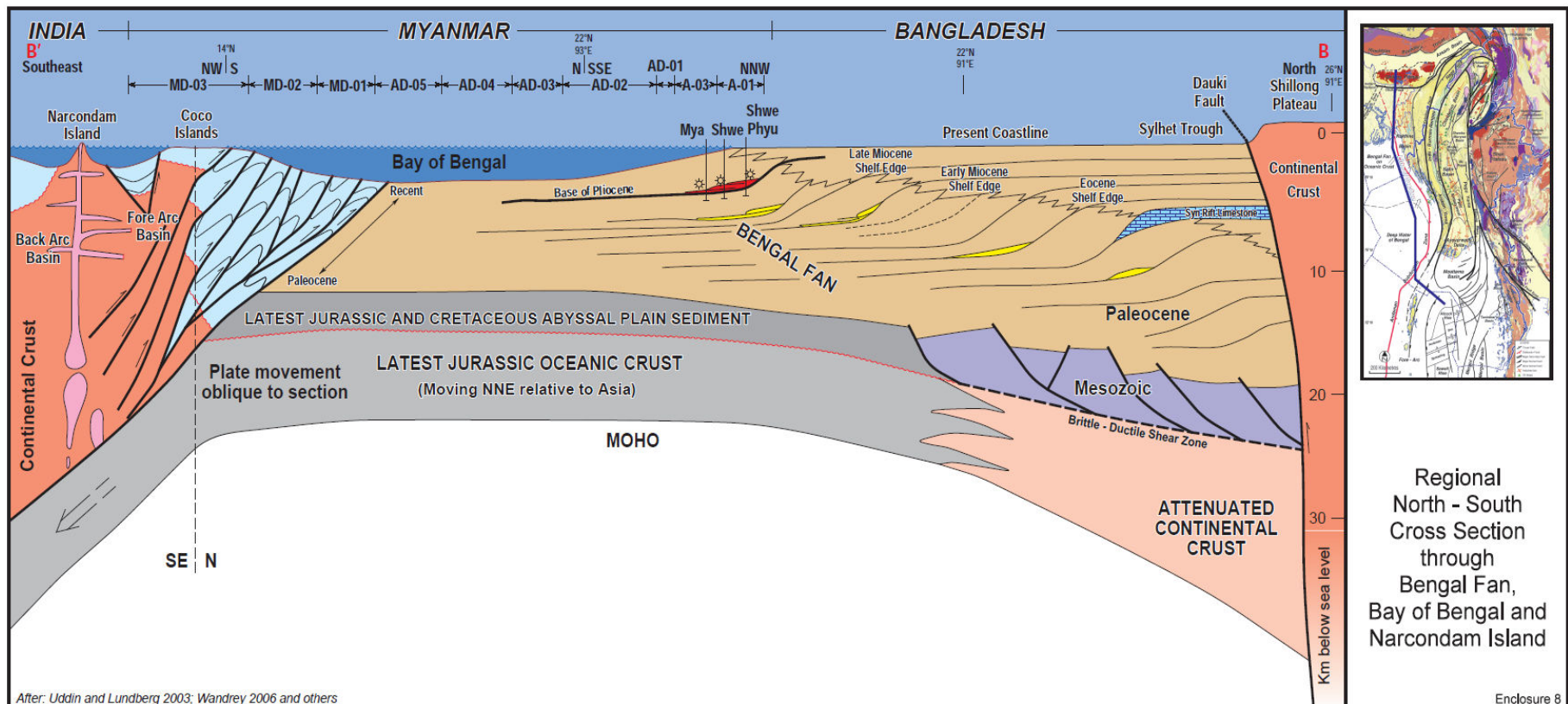
Onshore/offshore Rakhine Basin

- Cretaceous to Pliocene age basin located on the west coast of Myanmar - 1,000 km long, and extends into the Bay of Bengal where it is up to 200 km wide.
- Bounded to the east by the Indo-Burman Ranges and to the west by the ocean trench marking the northern extension of the Andaman Subduction Zone.
- Evolution of the basin was controlled by the oblique subduction of the Indian Plate beneath the Burma portion of the Eurasian Plate
- Rakhine Basin is the accretionary prism that developed as subduction proceeded from mid Eocene to Present



Onshore/offshore Rakhine Basin

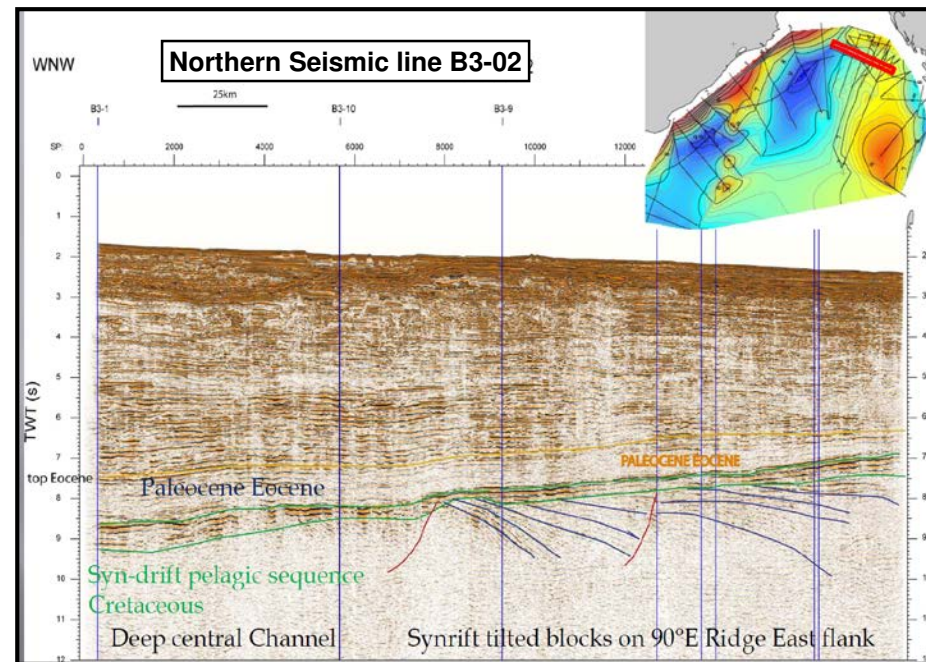
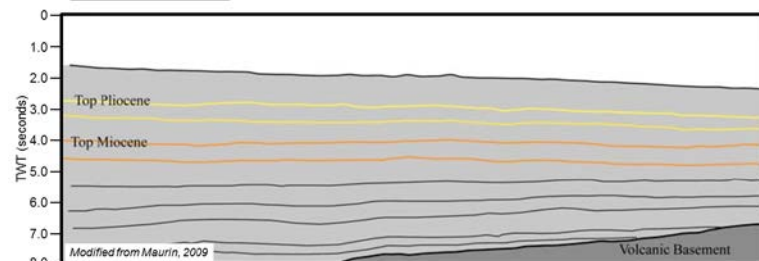
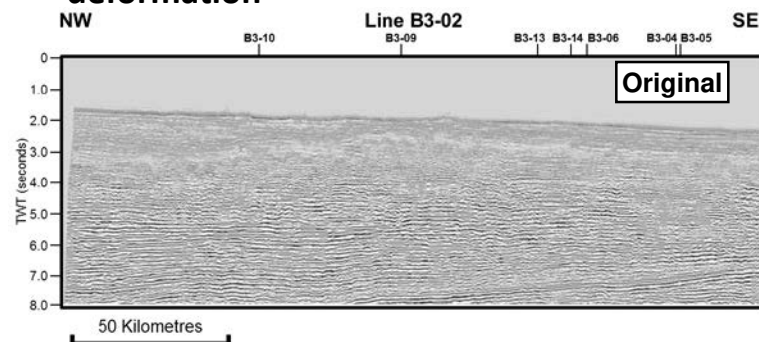
- The southern part of the Bengal Fan covers an area of 63,000 km² in offshore Myanmar and is the world's largest submarine fan system with a thickness exceeding 15 km
- Extends north into Bangladesh – truncated by the Dauki Fault at the southern margin of the Shillong Plateau
- In the south the Rakhine Basin narrows and merges with the Andaman fore-arc basin



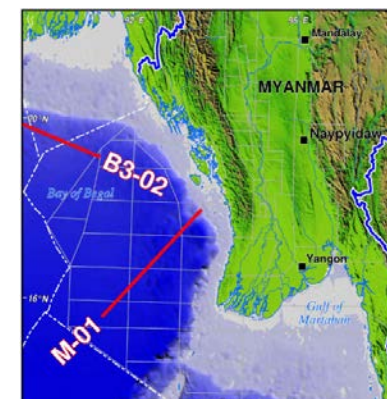
Rakhine Basin/Bengal Fan Regional Setting

Offshore Rakhine Basin: Northern Section

- Contrasting seismic sections, deep water Bay of Bengal, in the north with the south
- Water depth in the north 1,150 m, south 2,600 m
- Syn-rift Cretaceous section interpreted
- Basement in the north 7.0 sec, south 5.5 sec
- Miocene section north 4.0 sec thick, south 1.0 to 0.5 sec
- Northern seismic shows almost no structural deformation



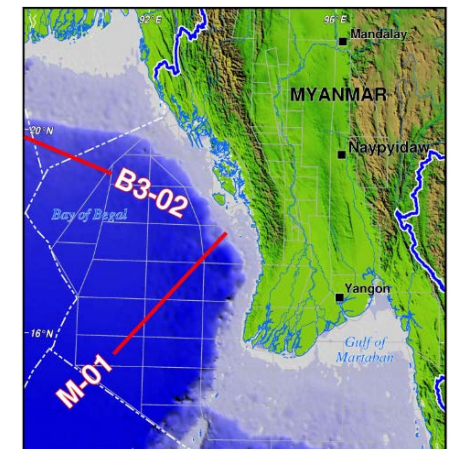
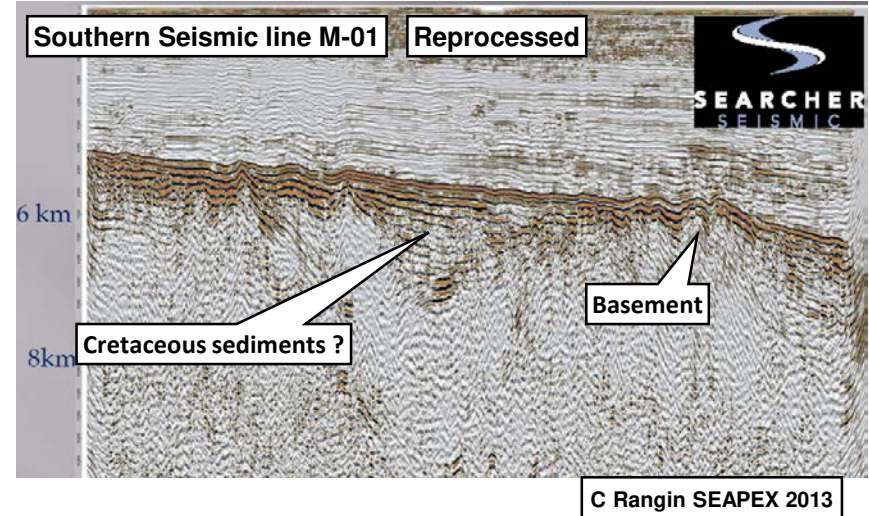
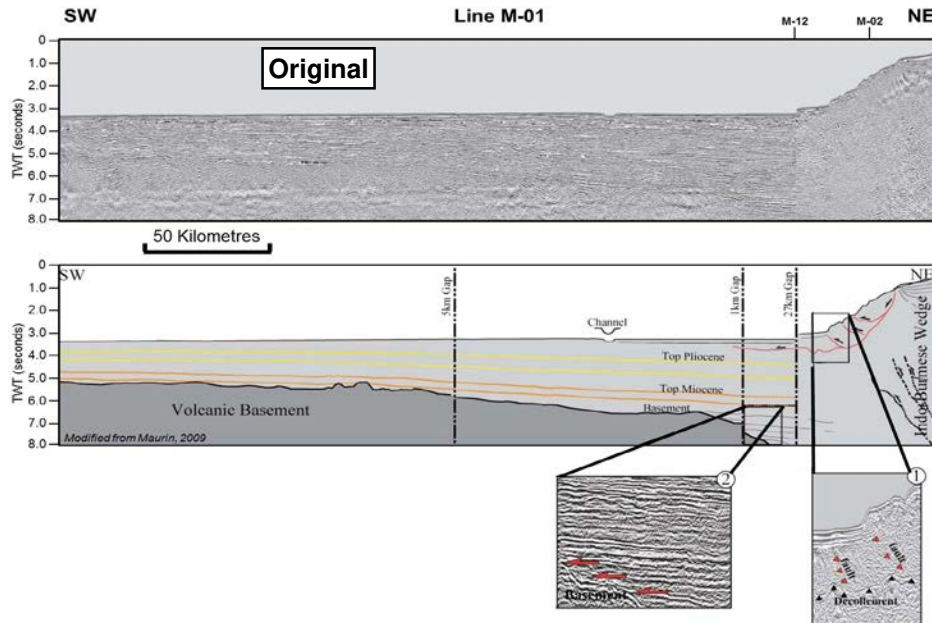
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Rakhine Basin/Bengal Fan Regional setting

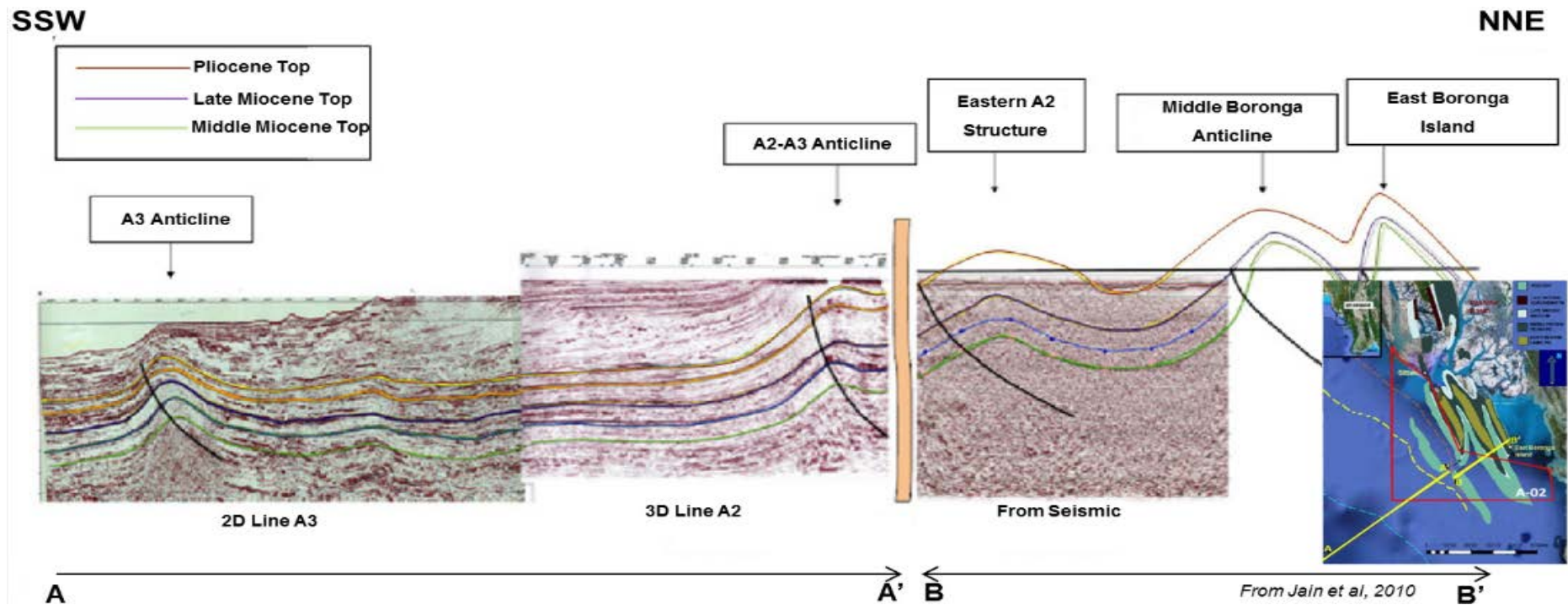
Offshore Rakhine Basin: Southern section

- Water depth in the south 2,600 m
- Syn-rift Cretaceous section interpreted
- Basement in the south 5.5 sec
- Miocene section, south 1.0 to 0.5 sec
- Southern line shows beginning of subduction zone and deformation in shallow section



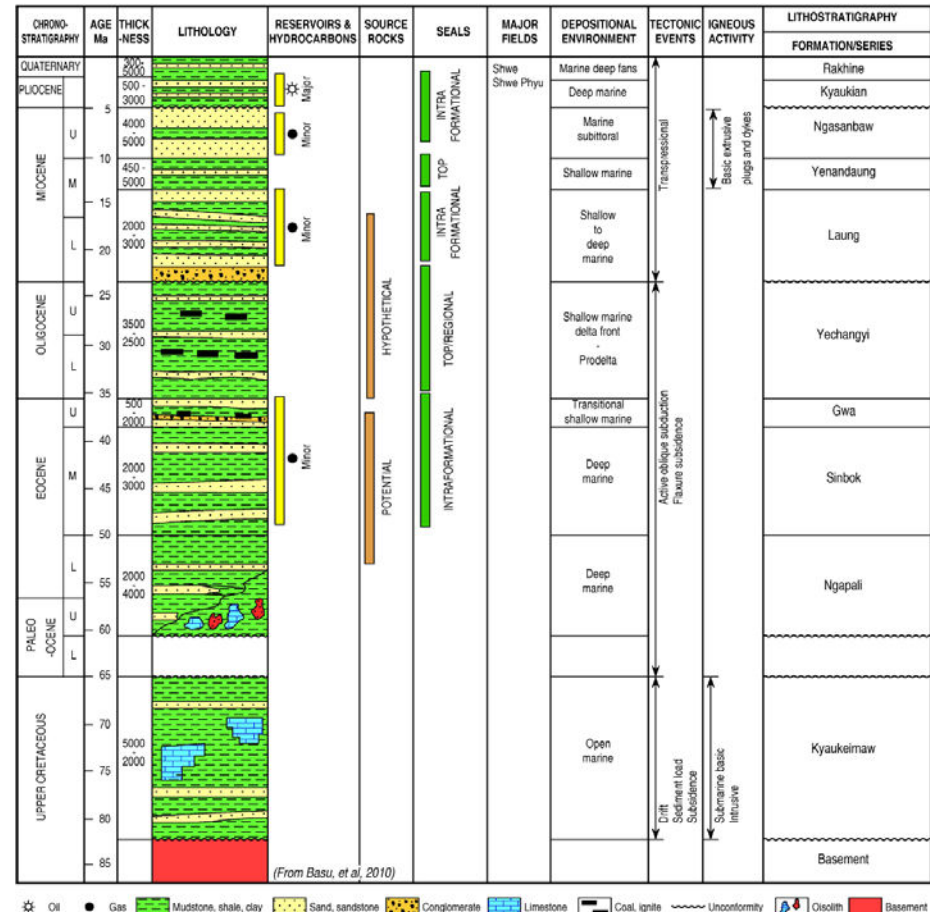
Onshore/offshore Rakhine Basin

- Highly folded and faulted structures are common in the near-shore area with the degree of deformation decreasing from east to west



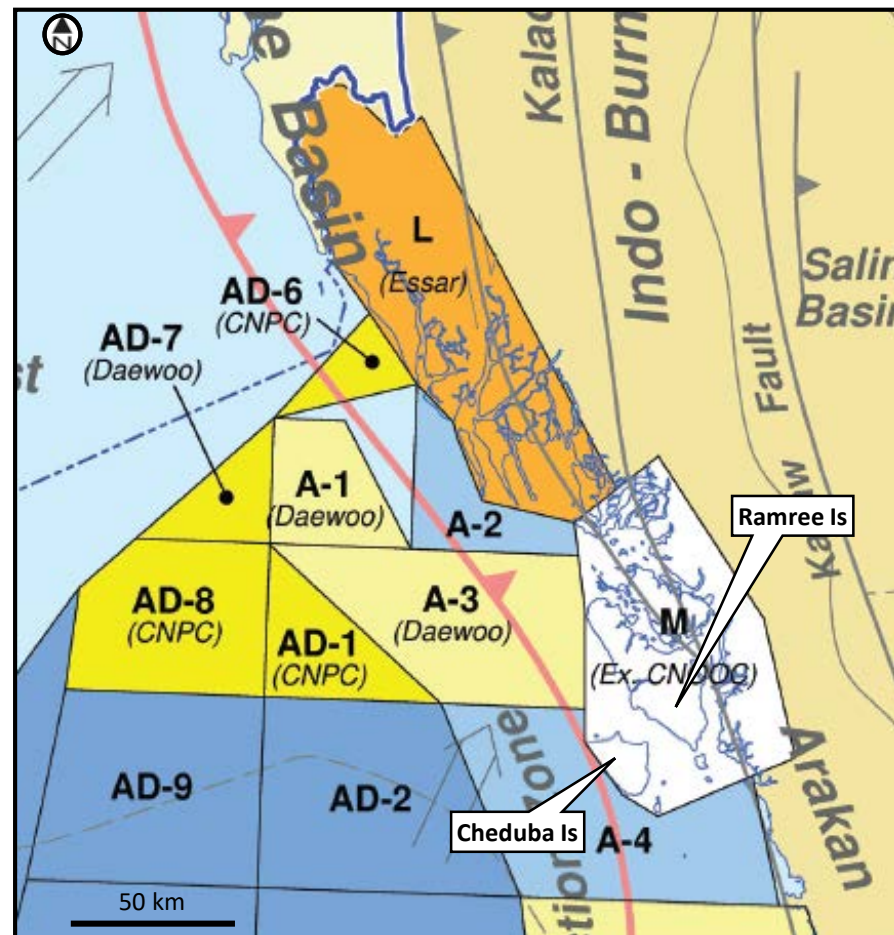
Three Petroleum Systems

- **Pliocene/Pleistocene Biogenic Gas – Shwe area**
 - Pleistocene to Miocene section in Shwe area immature for hydrocarbon generation
 - Modelling suggests gas generated from Mid Miocene to Early Pliocene shales
 - Pliocene reservoirs and seals
- **Eocene/Miocene Oil-onshore/near-shore area**
 - Oil on Ramree and Cheduba Islands produced from Late Miocene sands
 - Miocene and older aged source rocks capable of producing oil
- **Cretaceous Oil and Gas – hypothetical**
 - Interpreted source rocks – Cretaceous shales
 - Seismic data suggests potential oil mature sources rocks beneath the Shwe area which are similar to the onshore section
- **Reservoir is the primary geological risk for the basin however, 3D seismic amplitude extraction have been an effective exploration tool for reservoir presence**



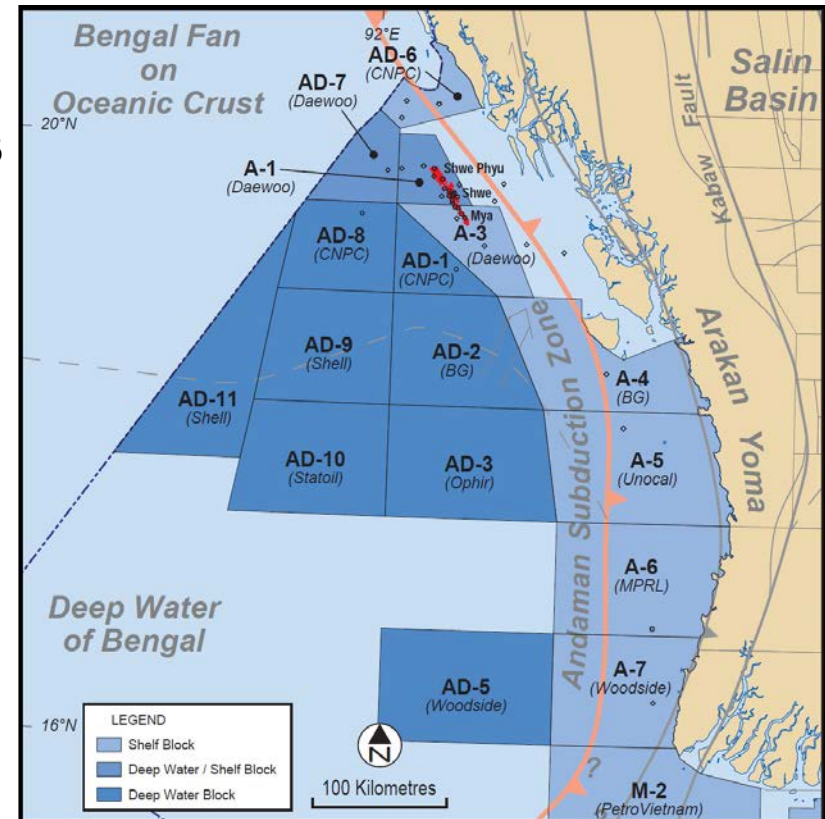
Onshore

- Mud Volcanoes and seeps of oil are common along the coast, particularly on Cheduba and Ramree islands
- Blocks L and M together with A-2 and A-4 were licensed to Essar and CNOOC in 2005 and 2004 respectively
- Essar acquired 3D in Block L in 2008
- CNOOC acquire 2D seismic in Block M and drilled 2 wells in 2006/07 but relinquished all blocks after drilling



Offshore

- Foreign companies allowed back - 1974
 - Arrakan Oil drilled 4 wells (3 with gas shows), 1975/76
 - Total drilled 2 wells (1 with good oil/gas shows)
 - Cities drilled 1 well (dry) in southern offshore
- All 1970's licensed blocks surrendered
- Exploration hiatus through 1980's and 90's
- Lack of good reservoirs and absence of oil in the early offshore wells deterred exploration for 20 years
- 2000 - Daewoo signed PSC for A-1 and drilled Shwe gas discovery well in 2003
- 2007
 - Daewoo signed PSC for A-3 & AD-7
 - CNPC awarded AD-1, -6, & -8
 - ONGC awarded AD-2, -3 & -9 but relinquished in 2011
- 2013/14
 - Offshore Myanmar gazettal round with 30 blocks offered
 - 6 Deepwater AD blocks awarded in the Rakhine Basin to majors: 2014
 - 3 Shallow water blocks awarded in the Rakhine Basin 2014



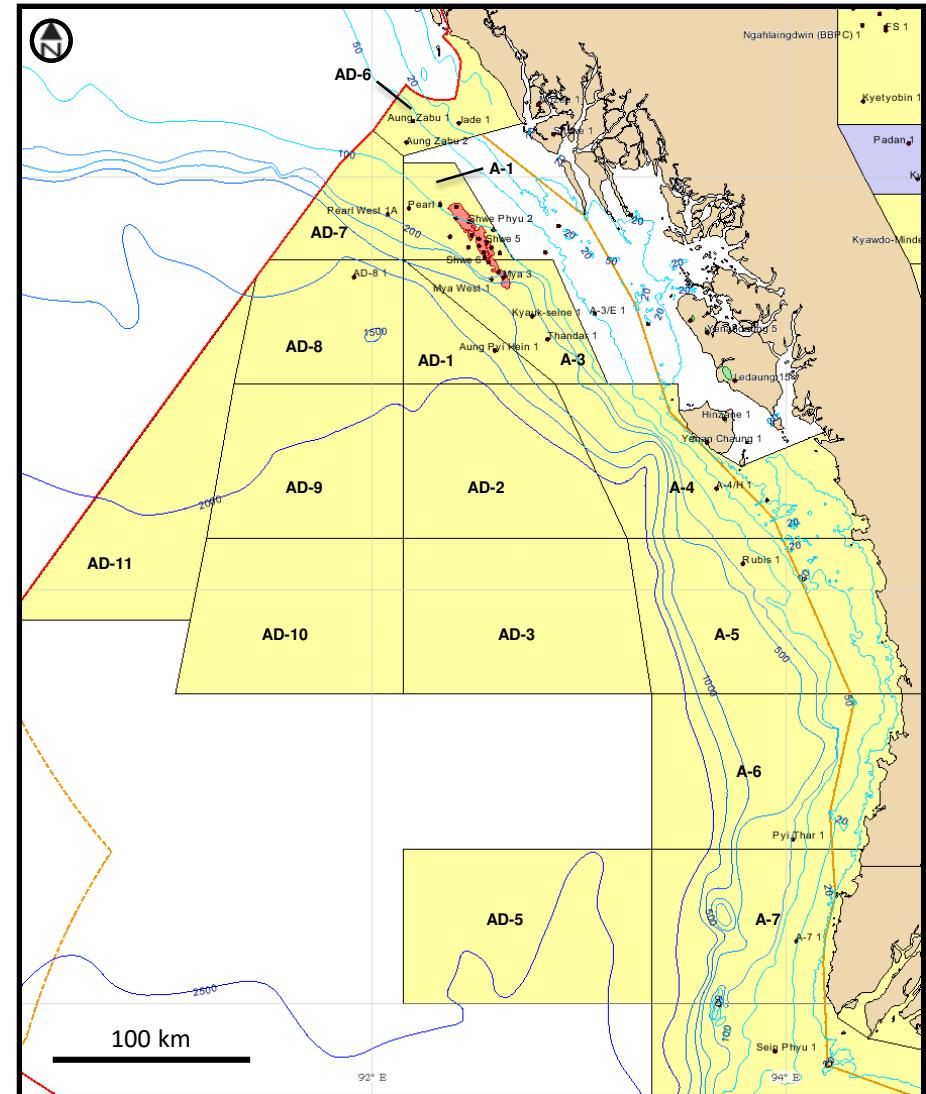
Wells

Exploration wells

- 16 (approx.) onshore
- 27 offshore exploration wells
- Most wells drilled in water depths <1,500 m
- Acreage very much under-explored by international industry standards
- Very little data is publicly available from exploration wells drilled to date

Appraisal Wells

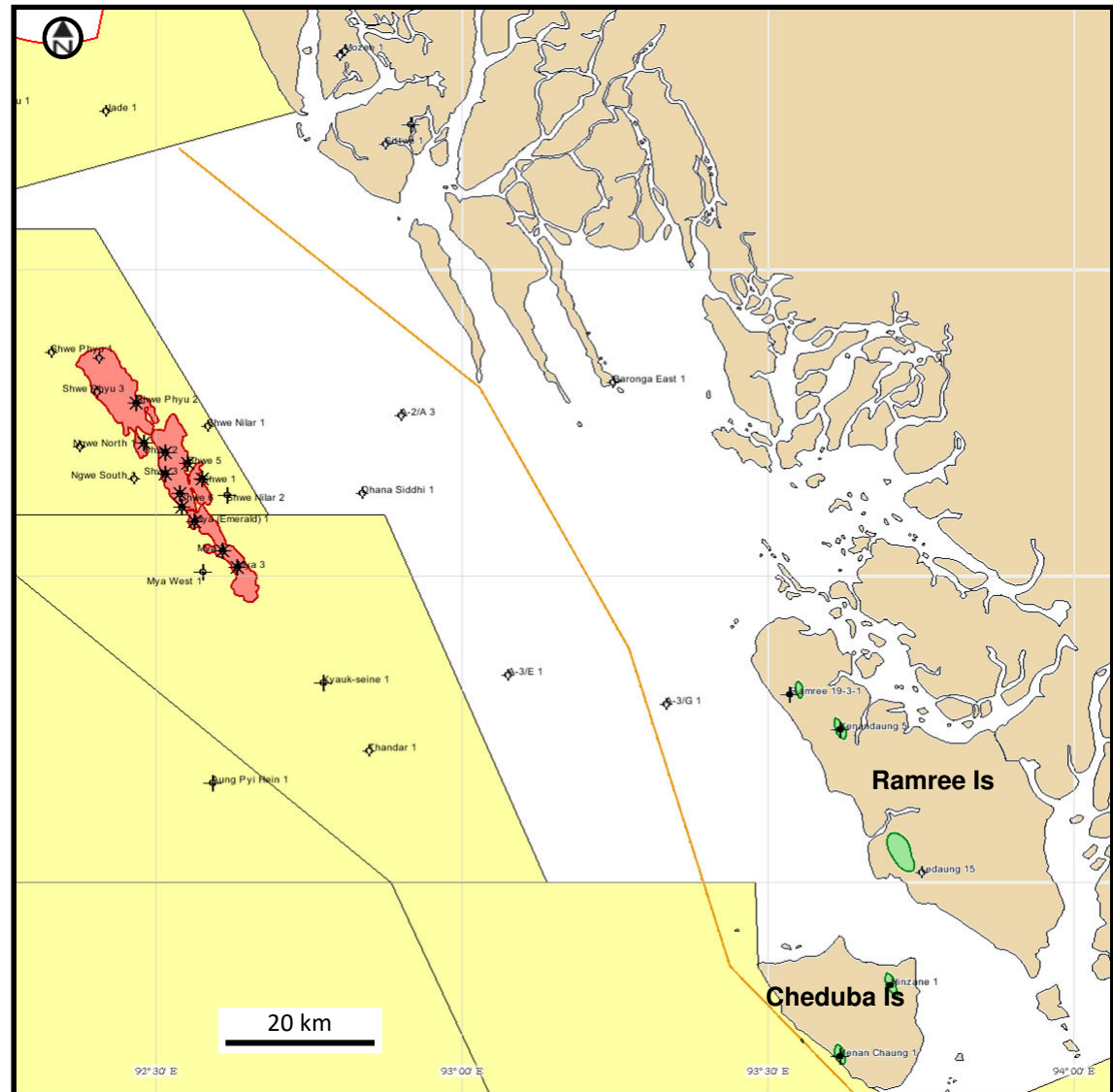
- Approximately 14 appraisal wells have been drilled in the Shwe, Shwe Phyu and Mya field areas.



Wells

Onshore Exploration wells

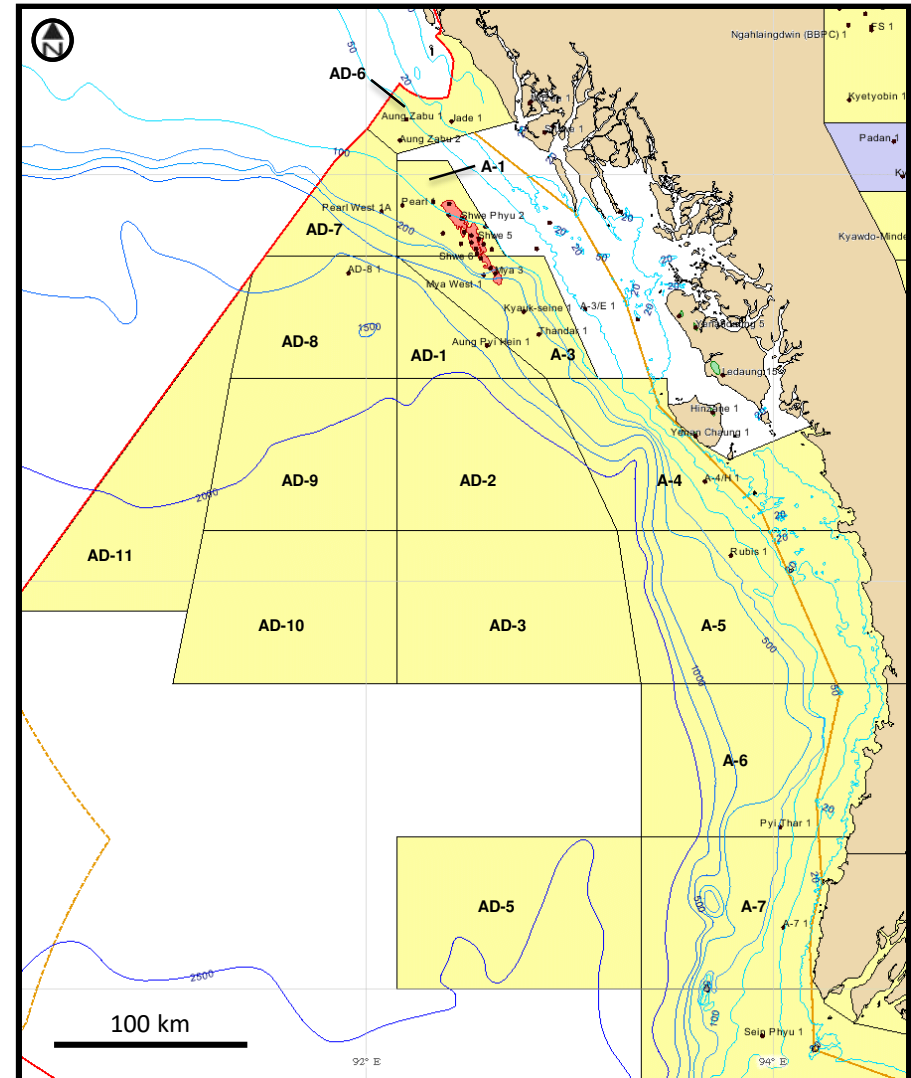
- Burmah Oil in the 1930's was the most active operator in the basin then MOGE in the 1970's & 80's
- Essar drilled 2 wells in 2009
- Oil production from Ramree and Cheduba Islands
- Oil - primary hydrocarbon
- Upper Miocene sandstones - primary target



Wells

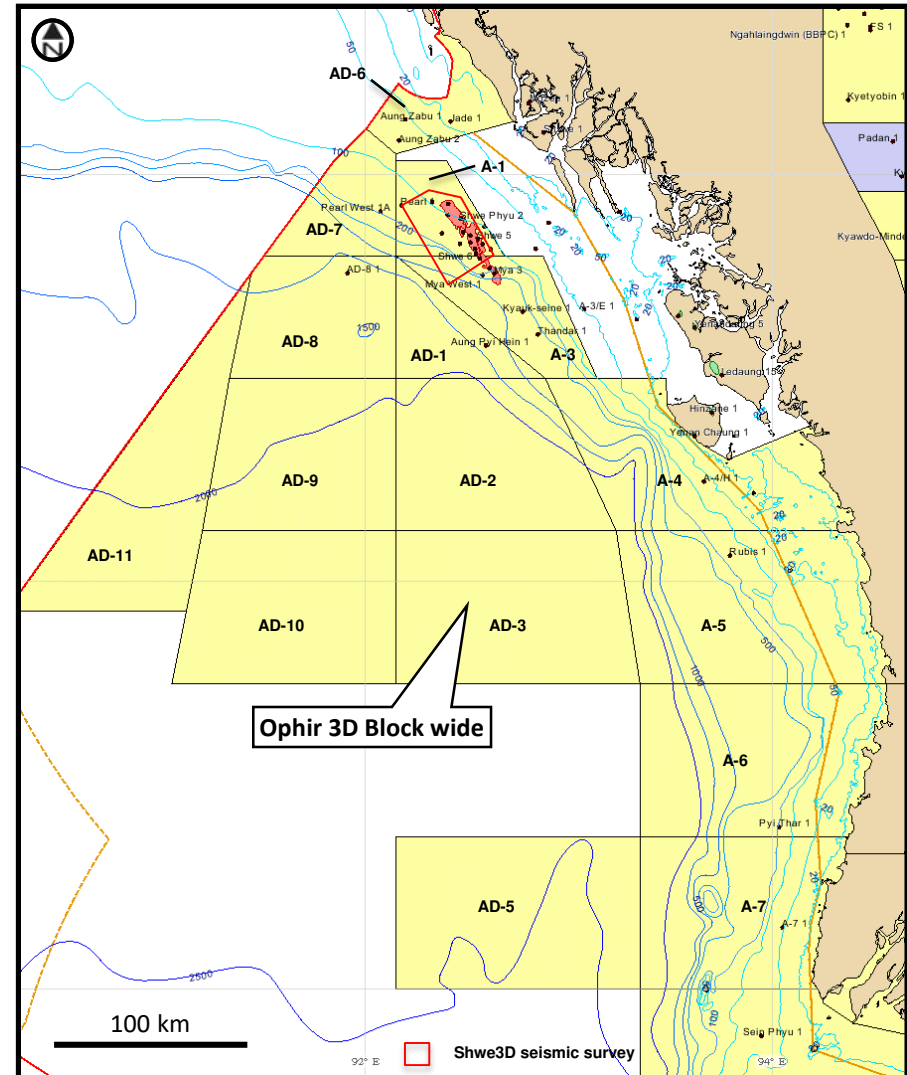
Offshore Exploration wells

- Daewoo is by far the most active operator in the basin with drilling focus 2005 to 08
- CNPC most active in last 2 years
- Gas - primary hydrocarbon
- The Pliocene sandstones - primary target
- Only 2 wells in 2012 & 2014
- Only 4 wells drilled in deep water blocks



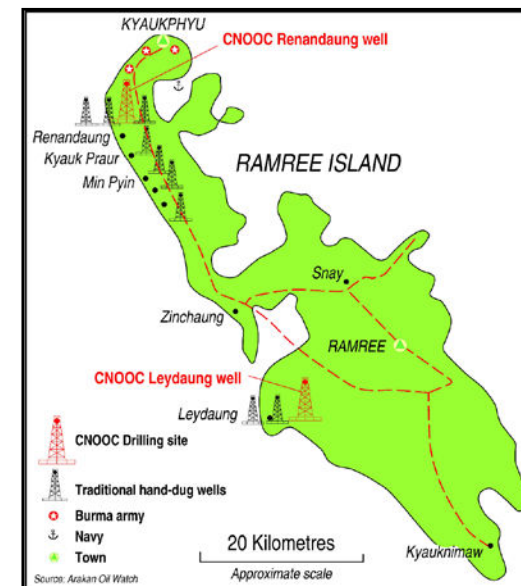
Seismic Data

- Extensive 2D seismic data has been recorded across the area but not publicly released
- A small number of 3D seismic surveys recorded
 - Especially by Daewoo across A-1 and A-3
 - Ophir currently shooting a block wide 3D survey (10,000 km²) with Dolphin using worlds widest streamer tow (12 km²) – prices down by 65%
- The Shwe 3D (1,195 km²)
 - instrumental in defining the nature of the stratigraphic trap across the field and indicating the extent and nature of the reservoir section with the use of seismic attribute maps.
- Most of the seismic data has not been made publicly available



Onshore

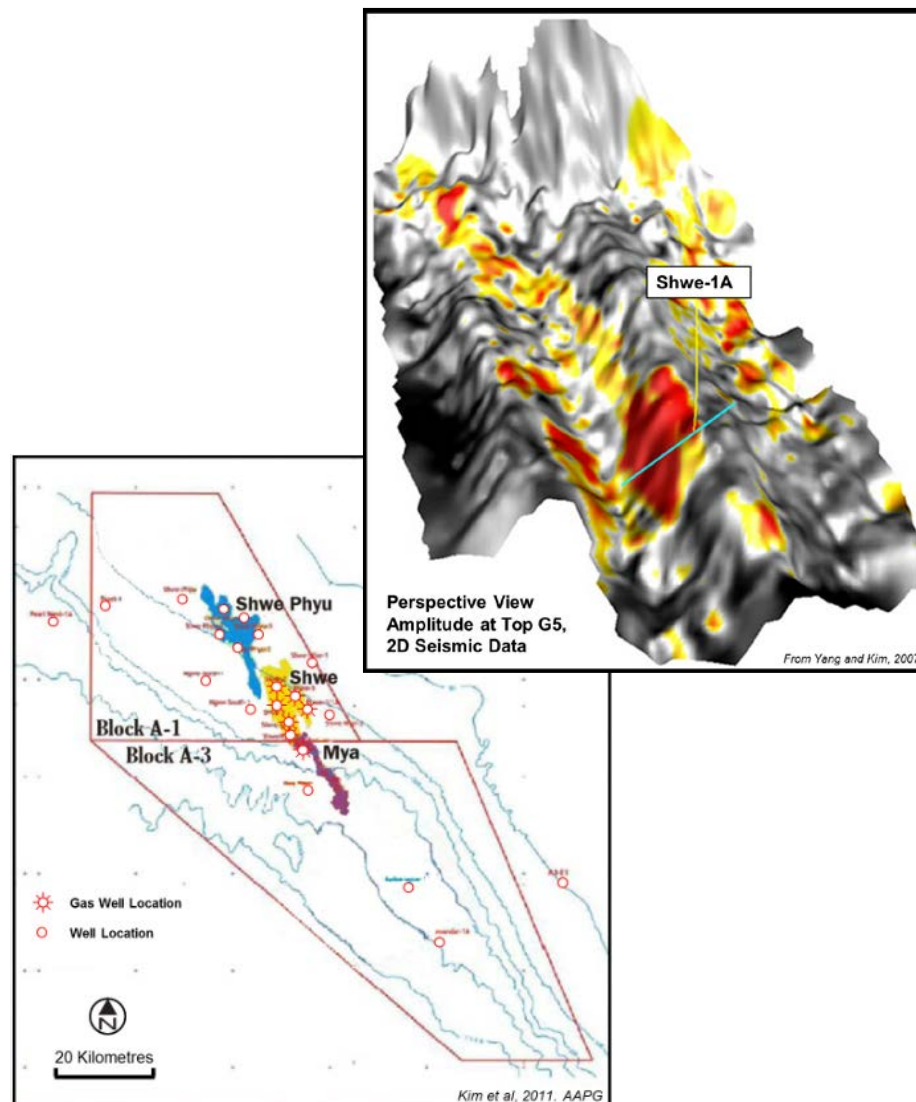
- Oil Fields on Boronga, Ramree and Cheduba Islands with production in 1925 of 1.7 BOPD from Ramree Is
- Yenandaung Oil Field in the northwest part of Ramree Is is a typical onshore field
 - Oil known from 1870's
 - Average depth of production 60m
 - Approx. 400 wells producing 8.6 BOPD in period 1876-1886
 - Estimated total production to 1981 was 730,000 bbl



CNOOC Rig at Renandaung-1 next to Traditional Hand Dug Wells

Offshore

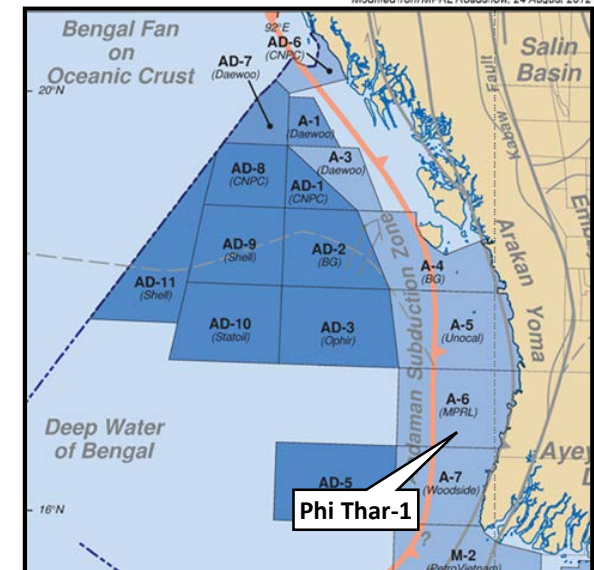
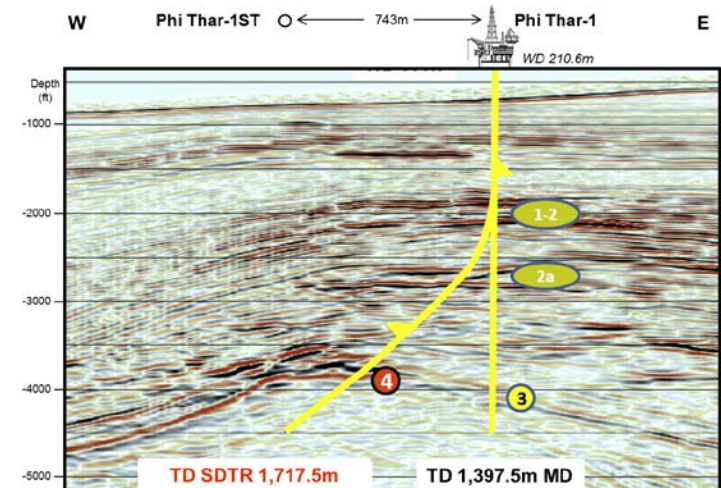
- Shwe, Shwe Phyu and Mya gas fields discovered by Daewoo in blocks A-1 and A-3
 - Drilled Shwe-1ST1 gas discovery 2002, after vertical well devoid of reservoir
 - Drilled Shwe Phyu gas discovery in 2005
 - Drilled Mya gas discovery in 2006
 - Reservoir – Early Pliocene deep water turbidite sands, sourced from the NW by a feeder channel, bring coarse sediments from the Ganges-Brahmaputra River systems
 - Trap – Structural / stratigraphic trap on SE plunging nose
 - Seal – Interbedded Pliocene shales
 - Source – Biogenic gas from Mid Miocene shales – dry gas > 99% methane
 - GIIP – 1P: 3.37 Tcf, 2P & 3P: 5.72 Tcf
 - Shwe production platform in 105m water and a 111 km/32" pipeline to Kuauk Phyu on Ramree island



Prospectivity of the Rakhine Basin/Bengal Fan

Rakhine Basin/Bengal Fan

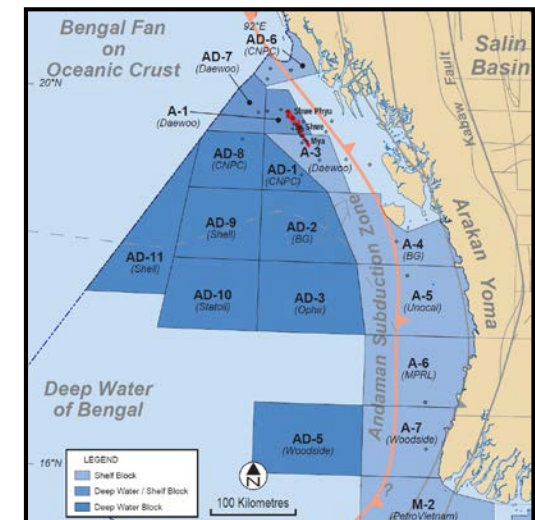
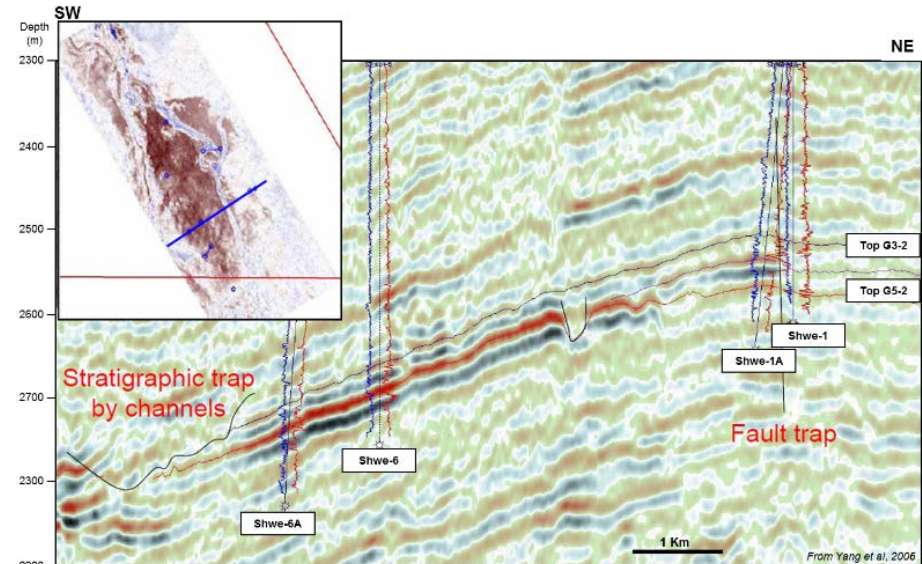
- Two proven petroleum systems –
 - Near-shore oil petroleum system :
 - The extent of the near-shore oil play is unknown but very likely extends across much of the shallow water areas
 - The area is structured into a series of en echelon anticlinal trends along which discrete structural closures are likely. The age of the structuring is Pleistocene to Recent
- The key to unlocking the potential of this oil play is modern high quality 3D seismic data interpreted with a view to identifying reservoir development as well as traps



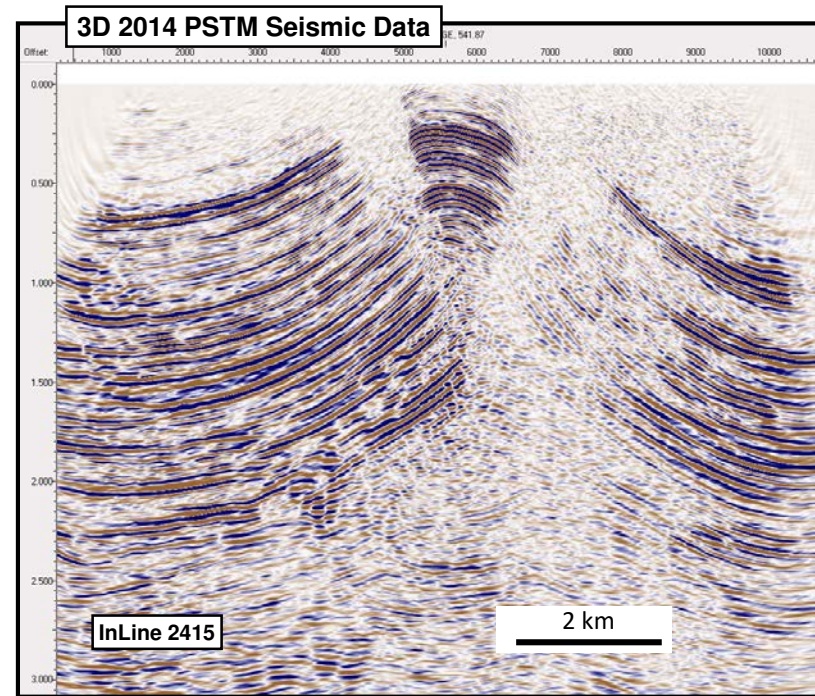
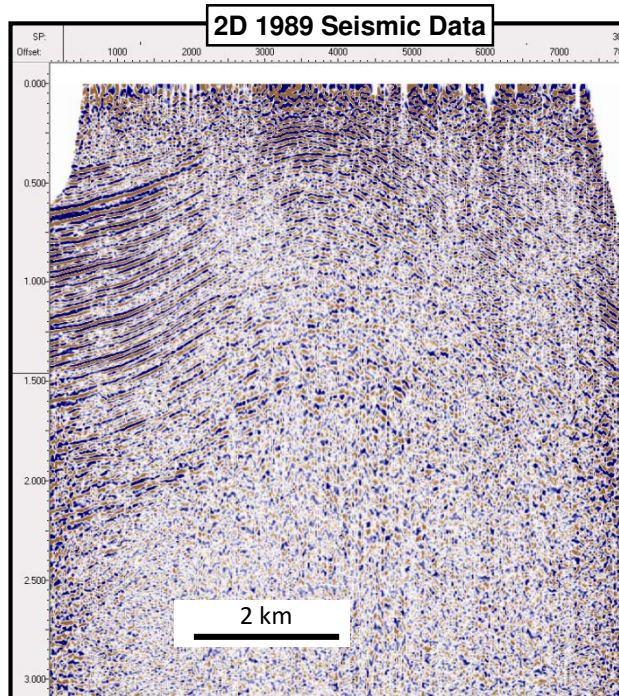
Prospectivity of the Rakhine Basin/Bengal Fan

Rakhine Basin/Bengal Fan

- Two proven petroleum systems –
 - Offshore Biogenic gas petroleum system:
 - The biogenic gas play developed in Bengal Fan sediments is proven in the Shwe area.
 - The three known fields are genetically related, being all part of the same Pliocene turbidite complex.
- There is every reason to believe that other Pliocene turbidite complexes exist in the area
- Modern 3D seismic data has proven itself across the Shwe discoveries and is a key exploration tool to delineate other systems in adjacent areas



3D Seismic Data: A Game Changing Step : Onshore Case



PSTM 3D Seismic Survey: Imaging is key

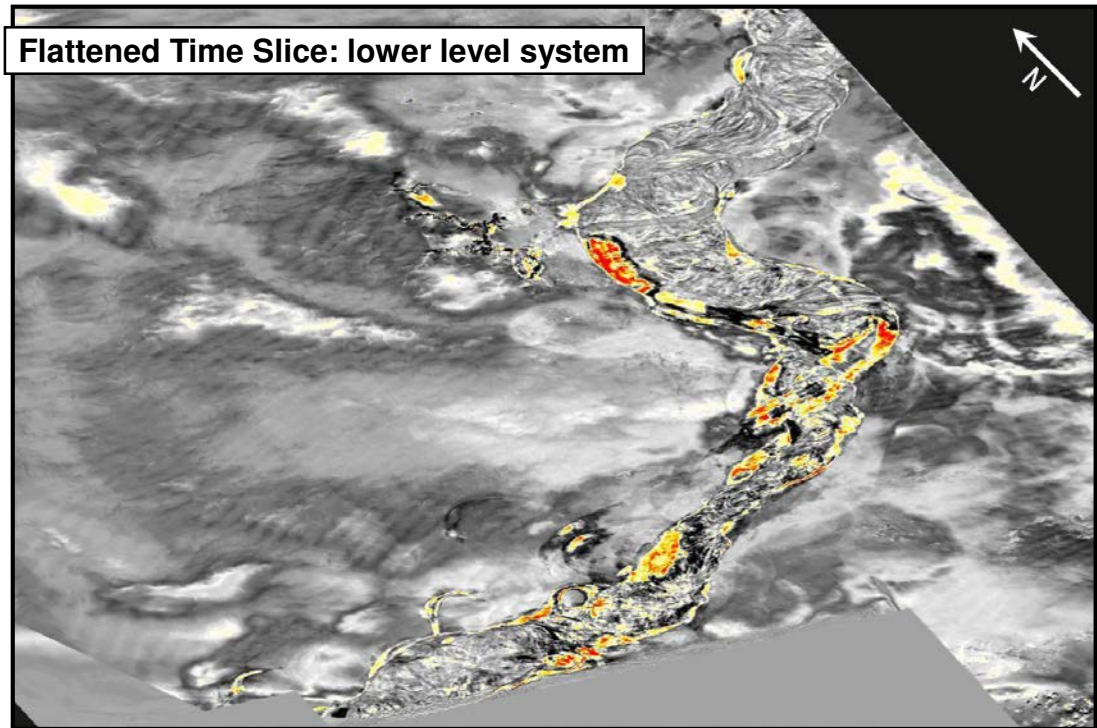
3D PSTM seismic data shows a vast improvement on the 2D data

- Structural imaging of the anticline
- Fault definition of thrust faults
- Resolution of reservoir targets
- Deeper targets better defined

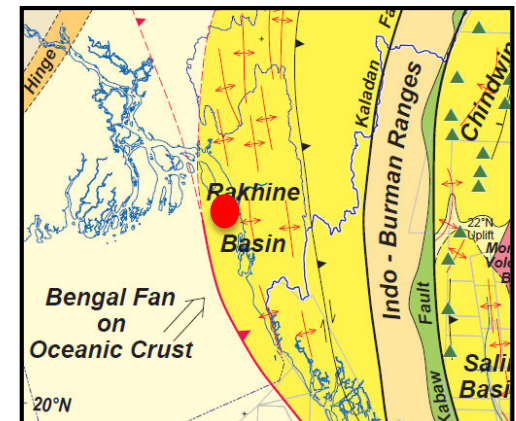
3D Seismic Data: A Game Changing Step : Offshore Case

3D Seismic Survey: Imaging is key

- 3D cube allows flattened time slices through the cube in order to image depositional systems
- Interpretation of environment of deposition maps greatly assists in reservoir predictions and characteristics
- 3D is a valuable tool for reducing geological risk for reservoir presence and quality
- 3D is essential for exploration in the mud rich offshore Rakhine Basin/Bengal fan

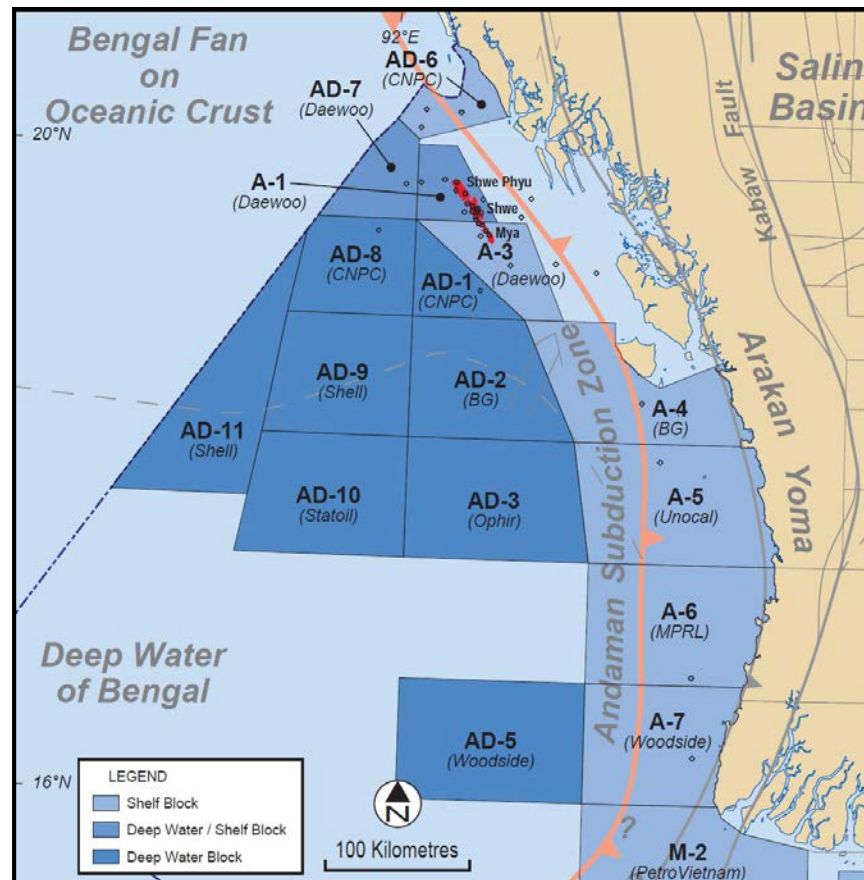


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Rakhine Basin/Bengal Fan

- Essential for success is to adopt the “hot air balloon” approach and integrate your block with the regional
- Not releasing open file exploration data has greatly hampered exploration in Myanmar
- Significant oil and gas potential still remain as Myanmar is considered vastly under-explored
- Two proven Petroleum Systems
 - Pliocene/Pleistocene Biogenic Gas system
 - Eocene/Miocene -onshore/near-shore Oil system
- Reservoir is the primary geological risk for the basin
- The key to unlocking the potential of the basin is modern high quality 3D seismic data
- The next 5 year offshore exploration phase will greatly increase our understanding of the geology and prospectivity of the basin



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- Geopetrol for the 3D onshore seismic examples



Useful Symbols

