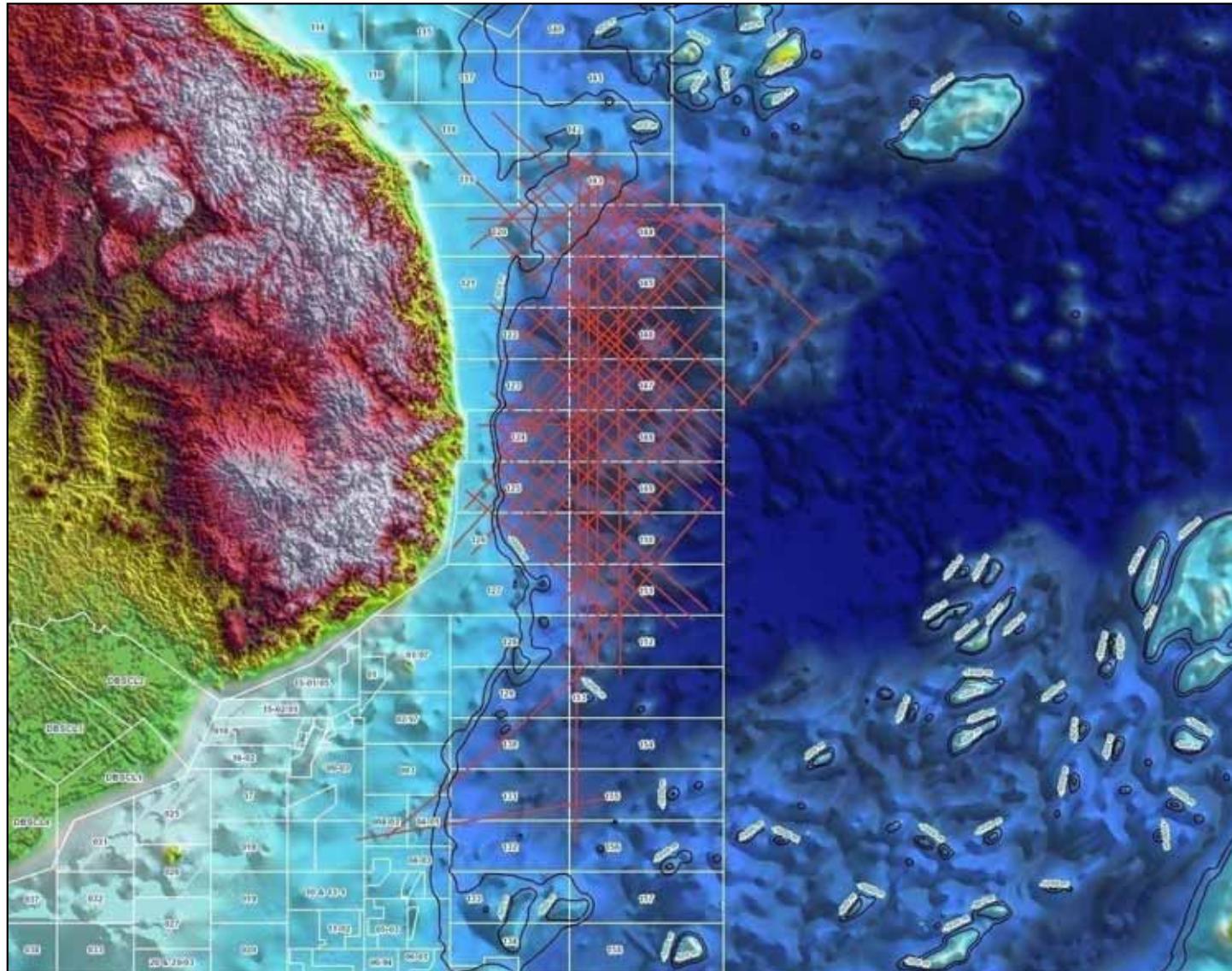
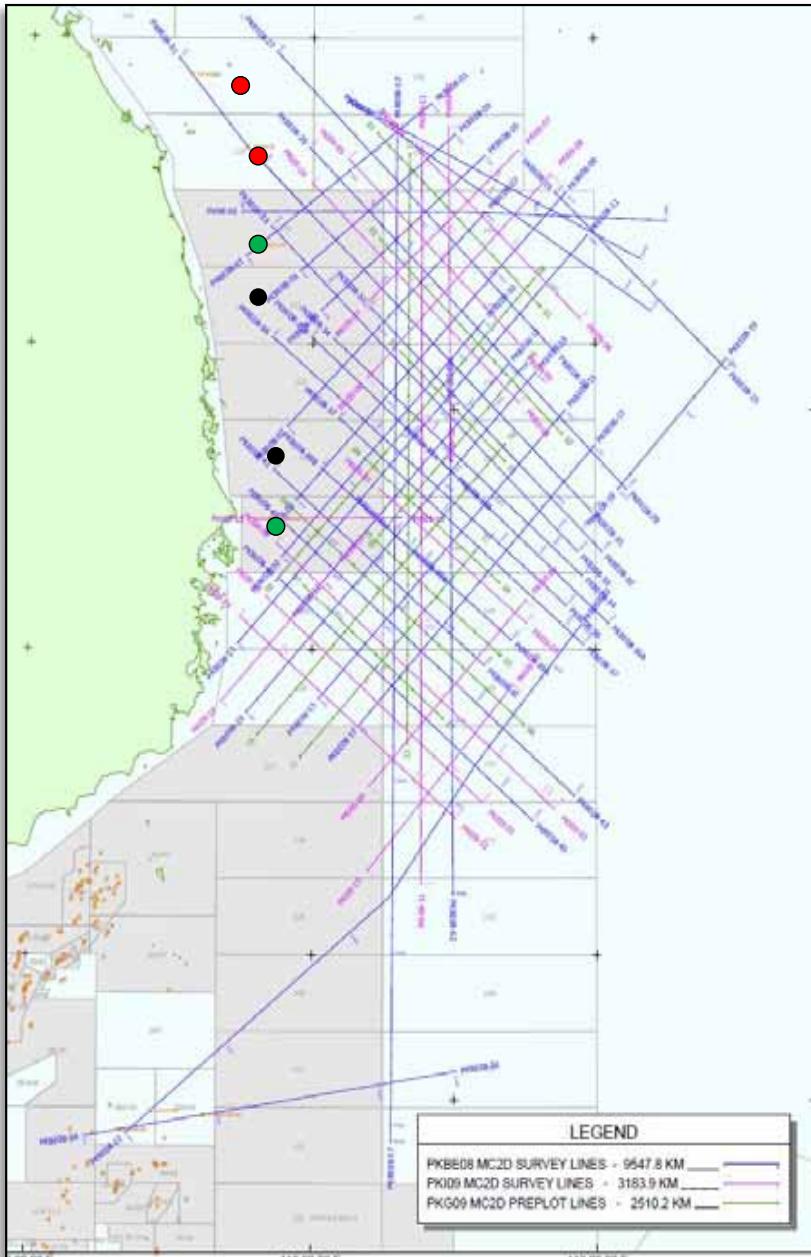


Co-authors;
Andrew Botsford
Suvi Maingarm

Introduction – Water depth



Water depth various
between 500 – 1500 m
in north, to 2000-2500
in central southern part



- The survey comprise ~ 14 500 km, acquired in 2008 and 2009
- Offset is 8km, with 9 and 11 s TWT recording time.
- Seismic grid is about 10-15+ km

- Dry well
- Gas wells
- Oil wells

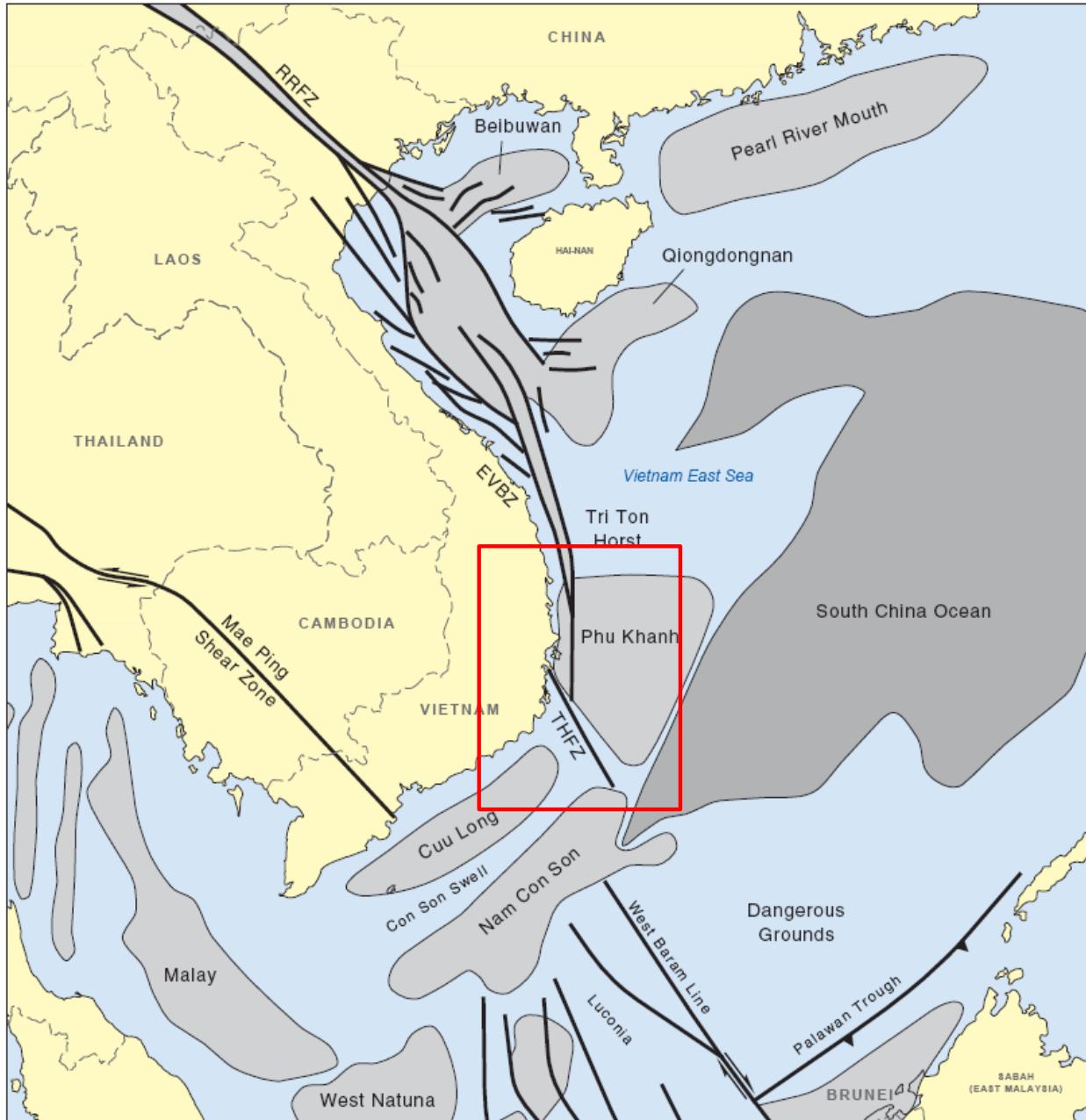
Phu Khanh Basin, offshore Vietnam; One of the Last Frontier Areas in SE Asia

Outline of the talk

1. Introduction
2. Stratigraphy and Basin Development
3. Geochemistry/source rocks - observations
 - CO₂ challenges
4. Examples of leads
5. Summary



Introduction - Main Structural Elements



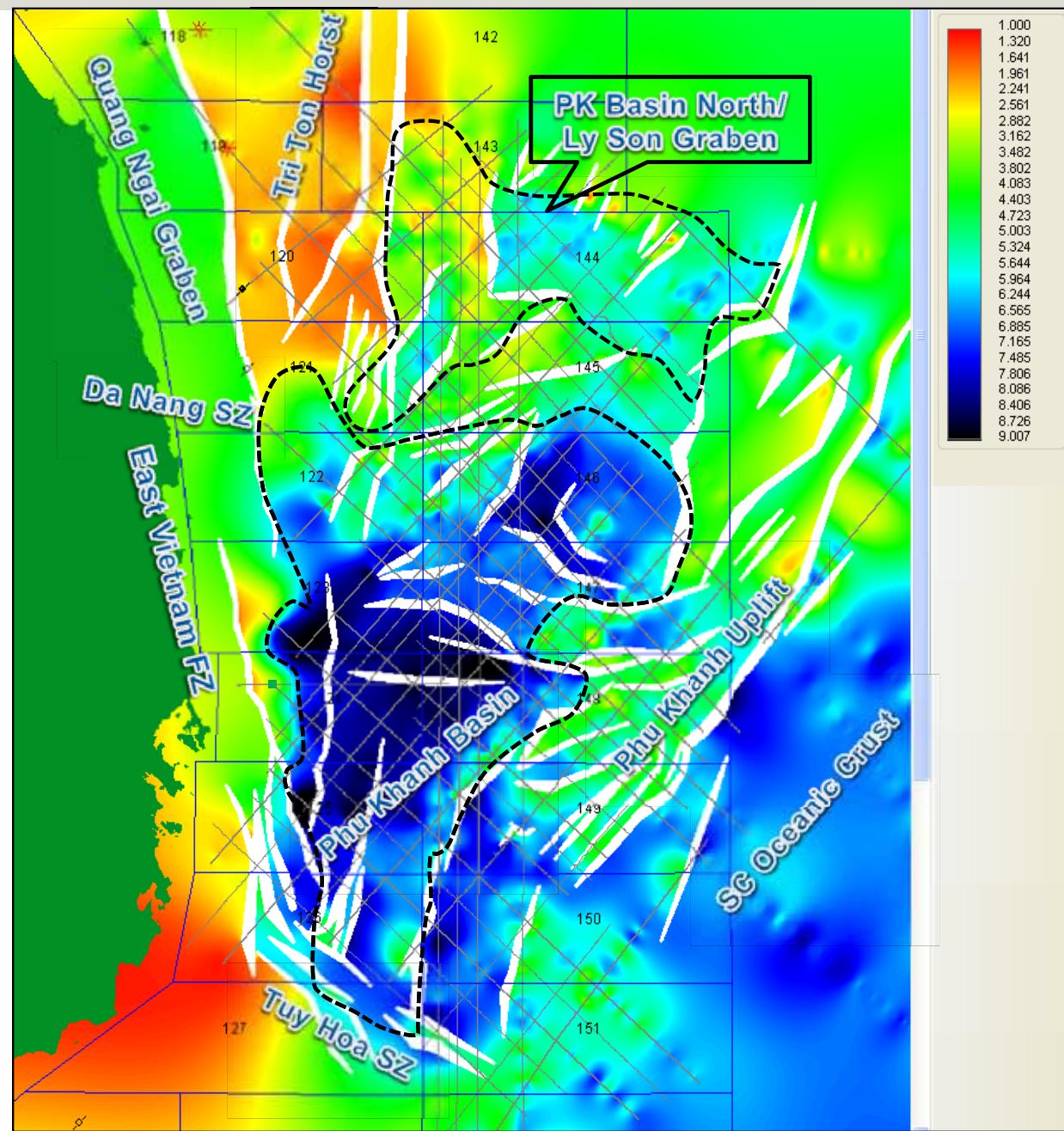
Modified from Fyhn, et al, 2009

B. Tertiary TWT map – main structural elements

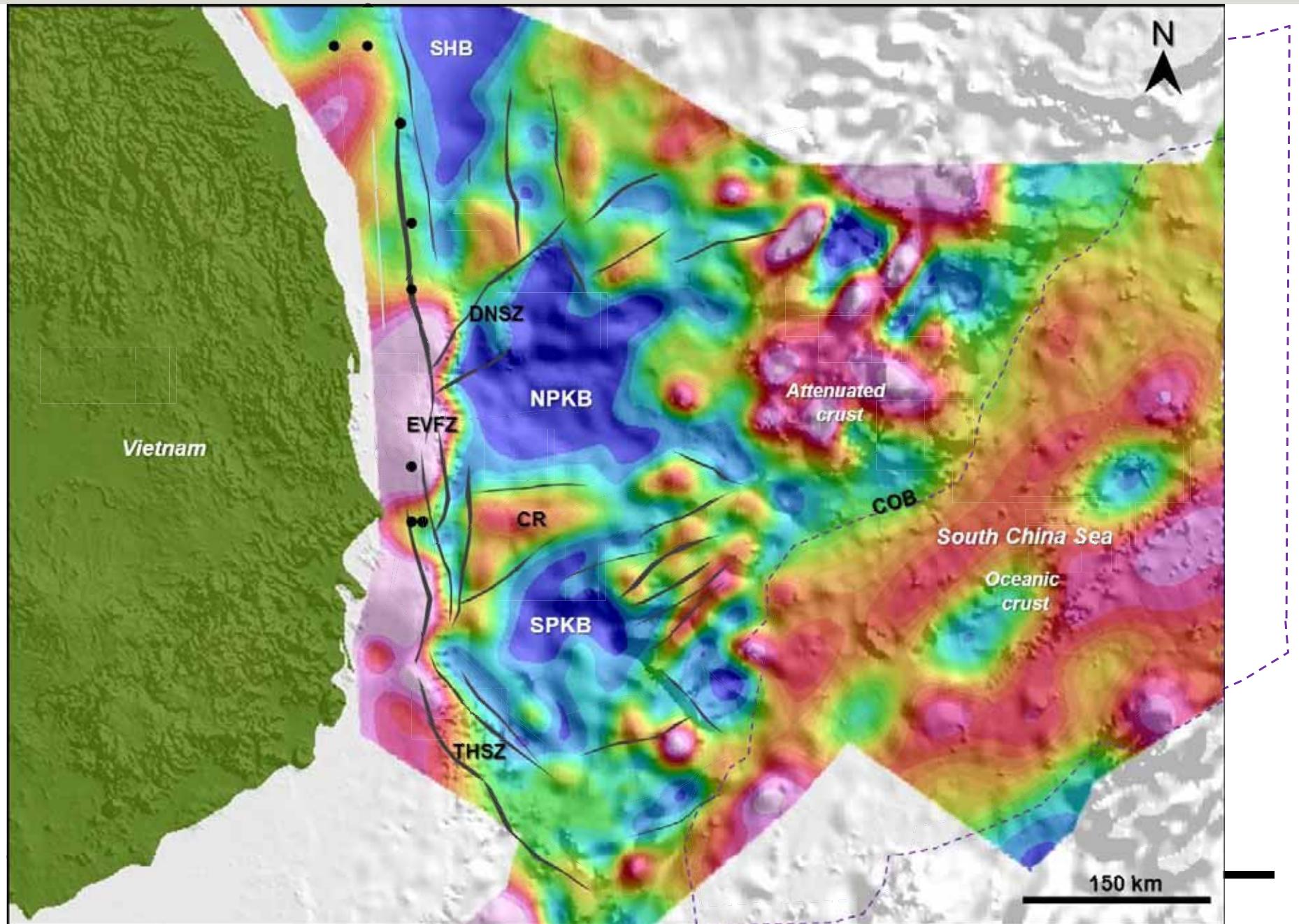
Phu Khanh Basin
area ~ 80 000 sq km

Four different fault trends;
W-E/NW-SE is younger than N-S and NE-SW.

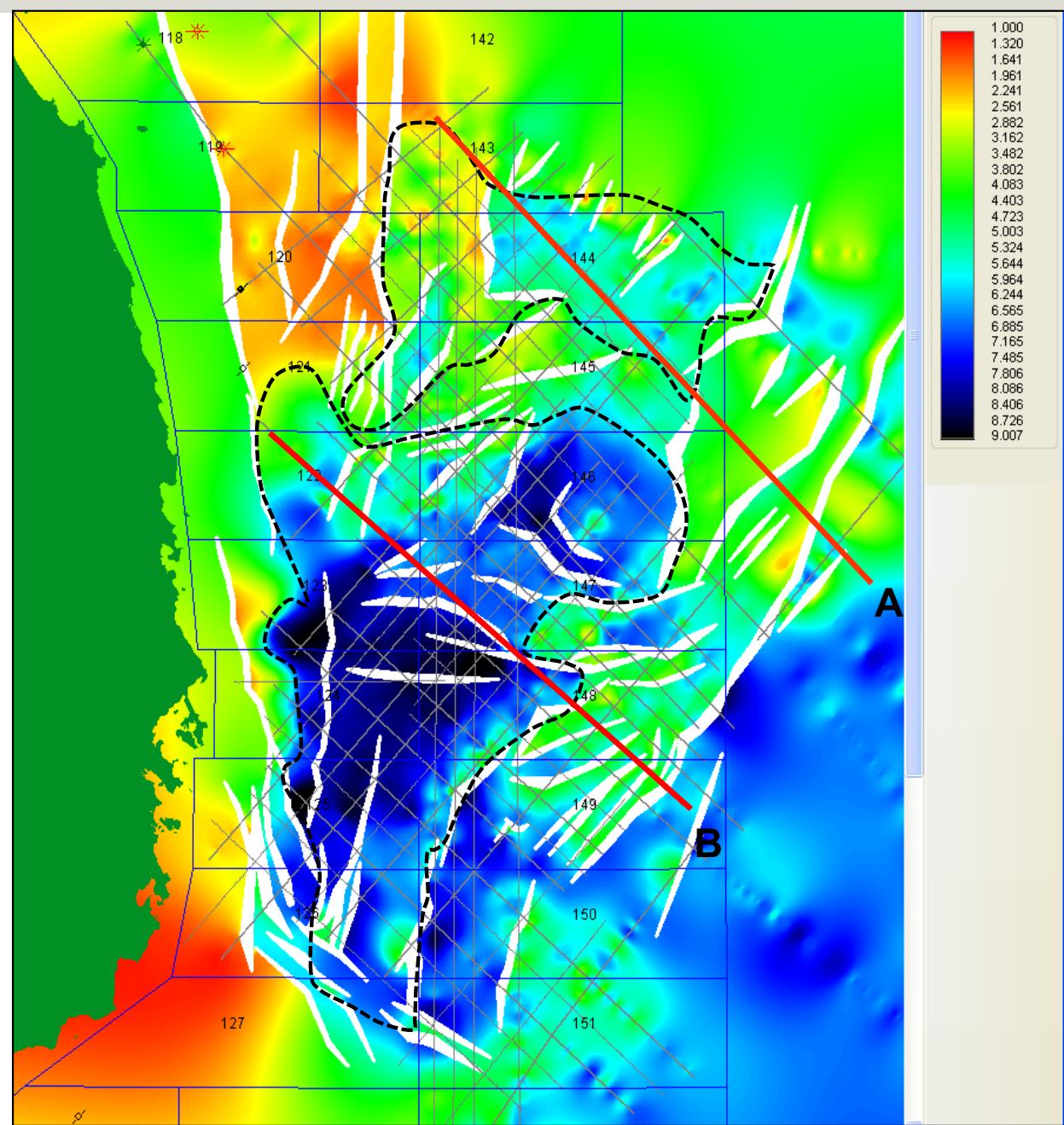
Southern area has up to 8 km of sediments, while northern area, 4-6 km



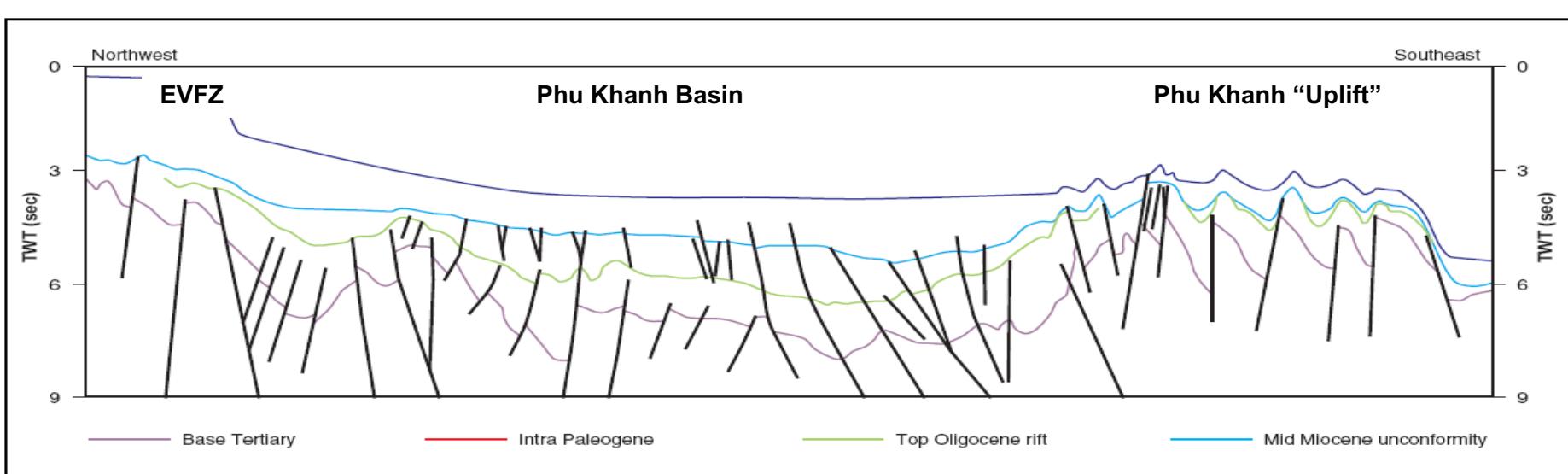
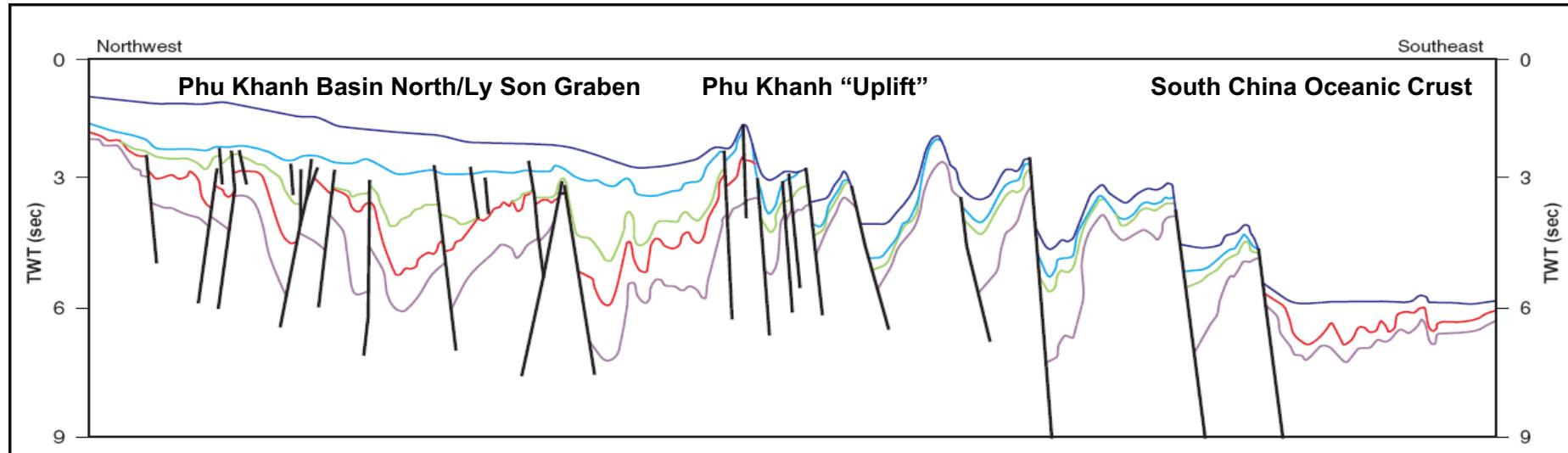
Marine Free air gravity



B. Tertiary map – line locations



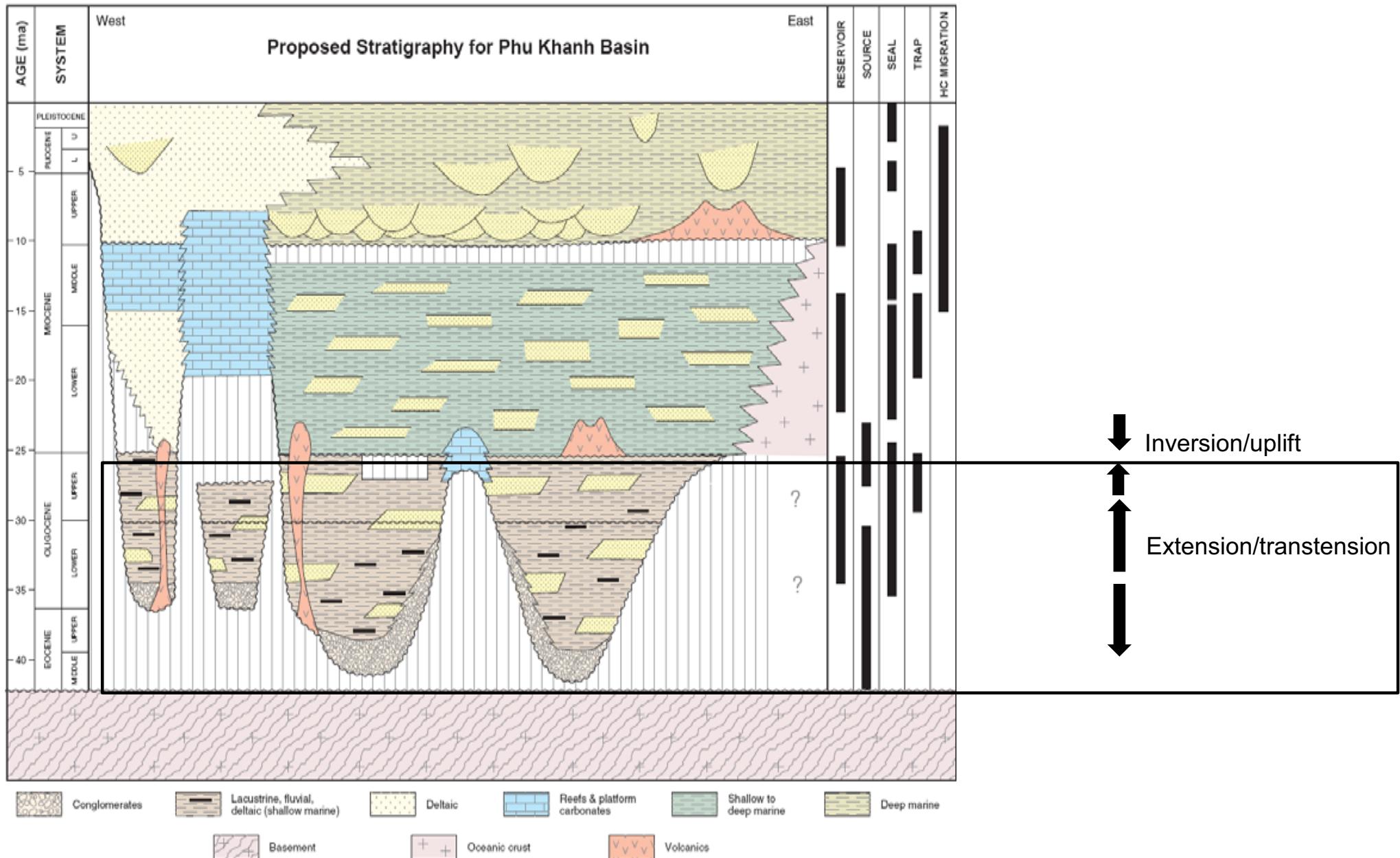
Phu Khanh Basin – Main structural elements



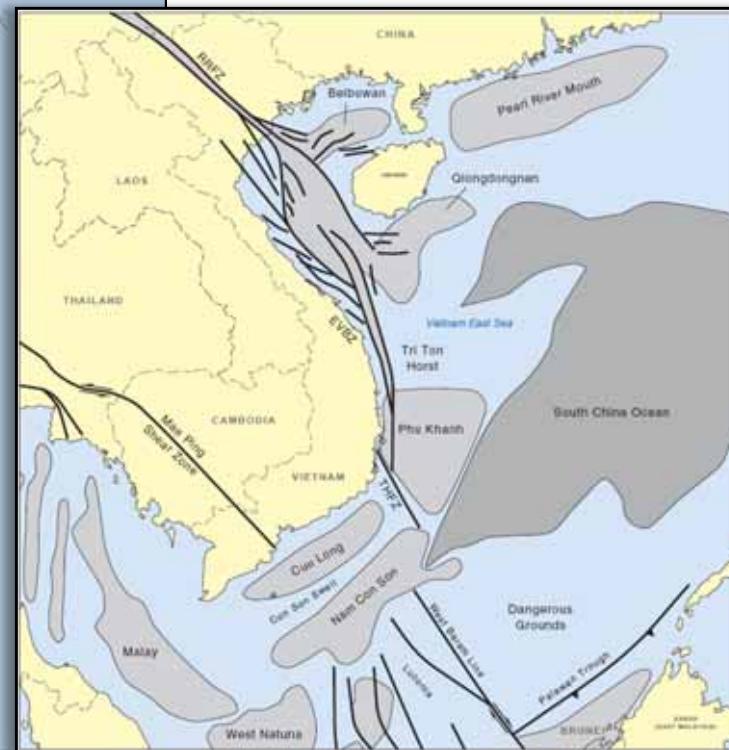
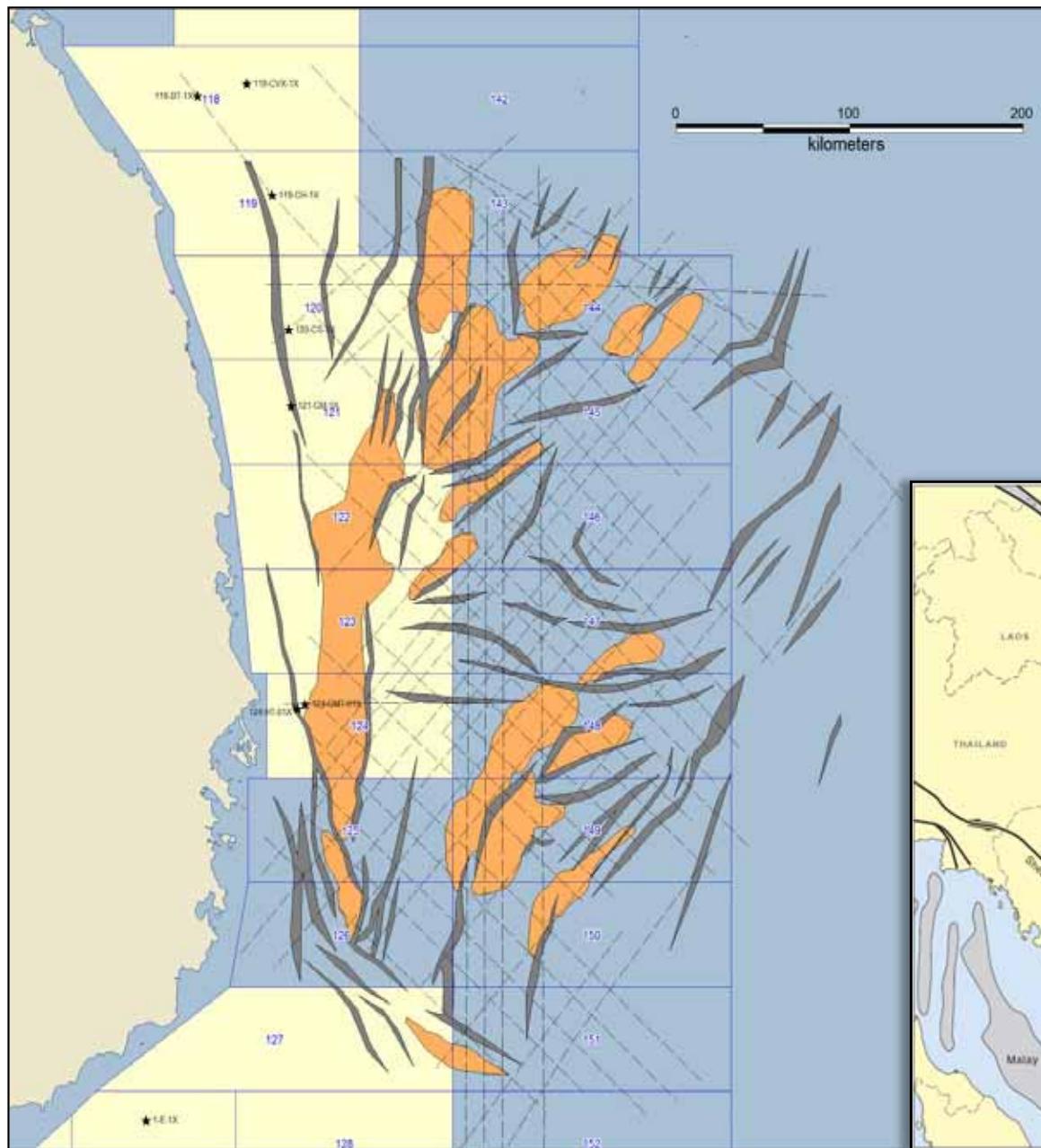


Stratigraphy and Basin Development

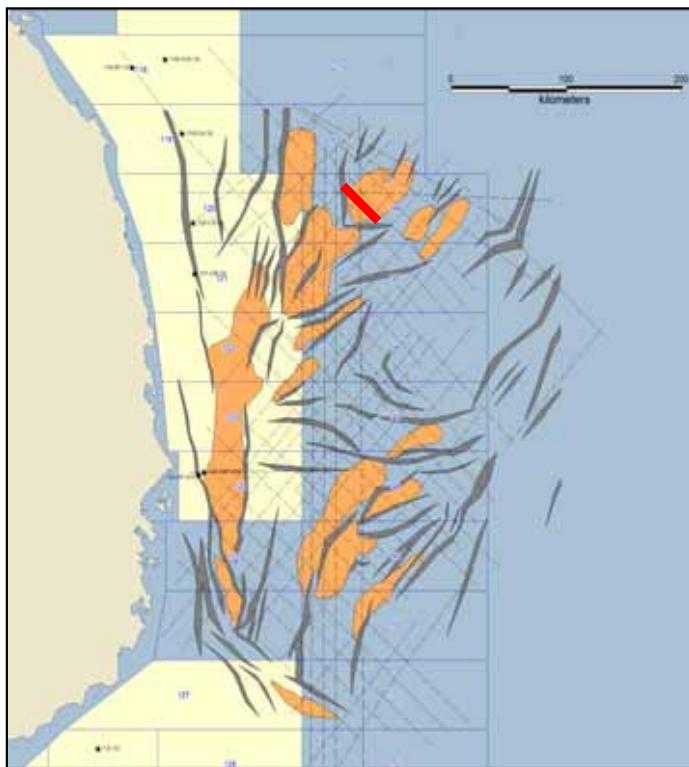
Stratigraphy and Basin Development



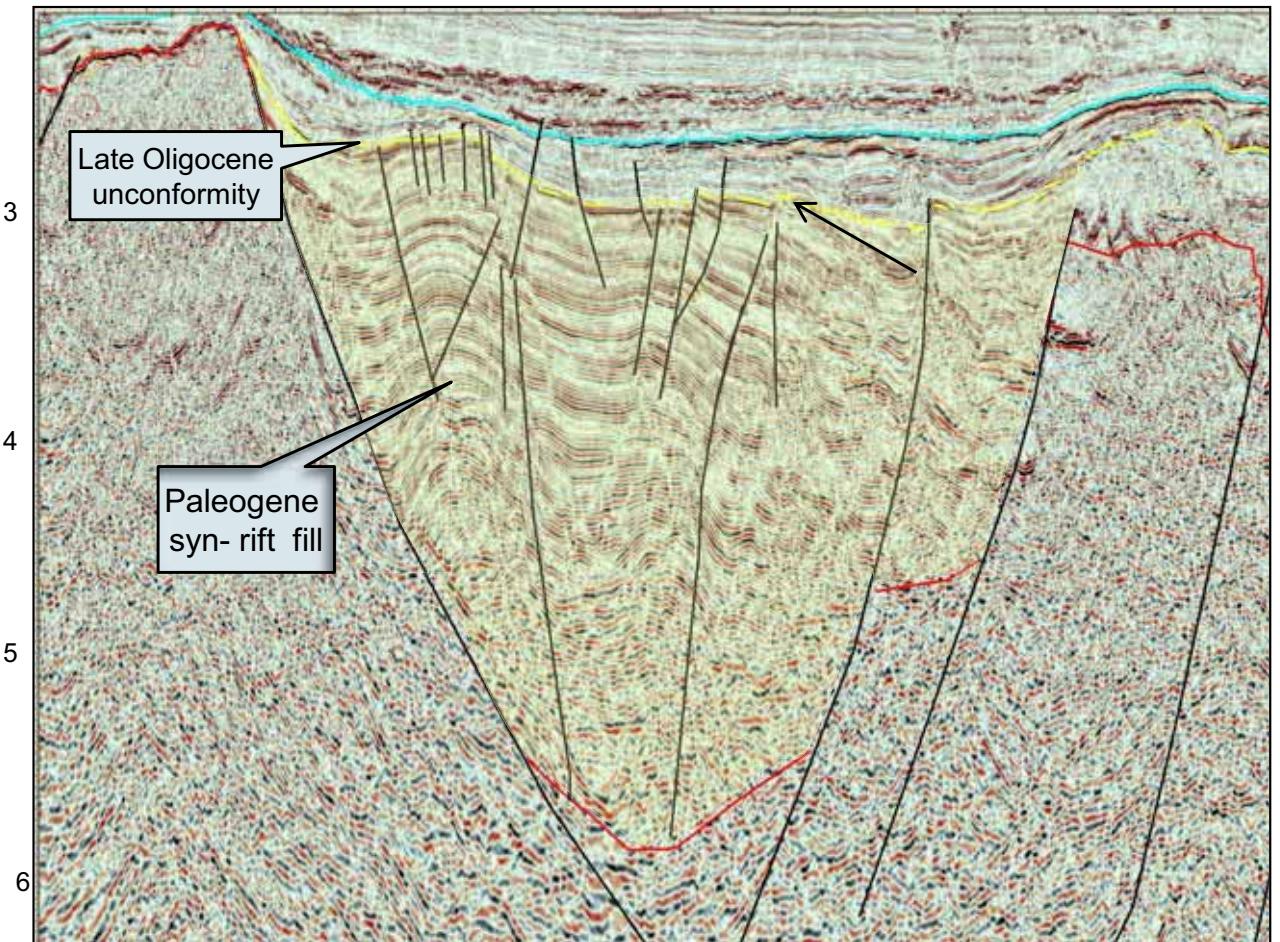
Outline of Eocene – Late Oligocene (?) syn- rift fill



Eocene – Late Oligocene (?) syn- rift fill



Rift fill is more than 3 km

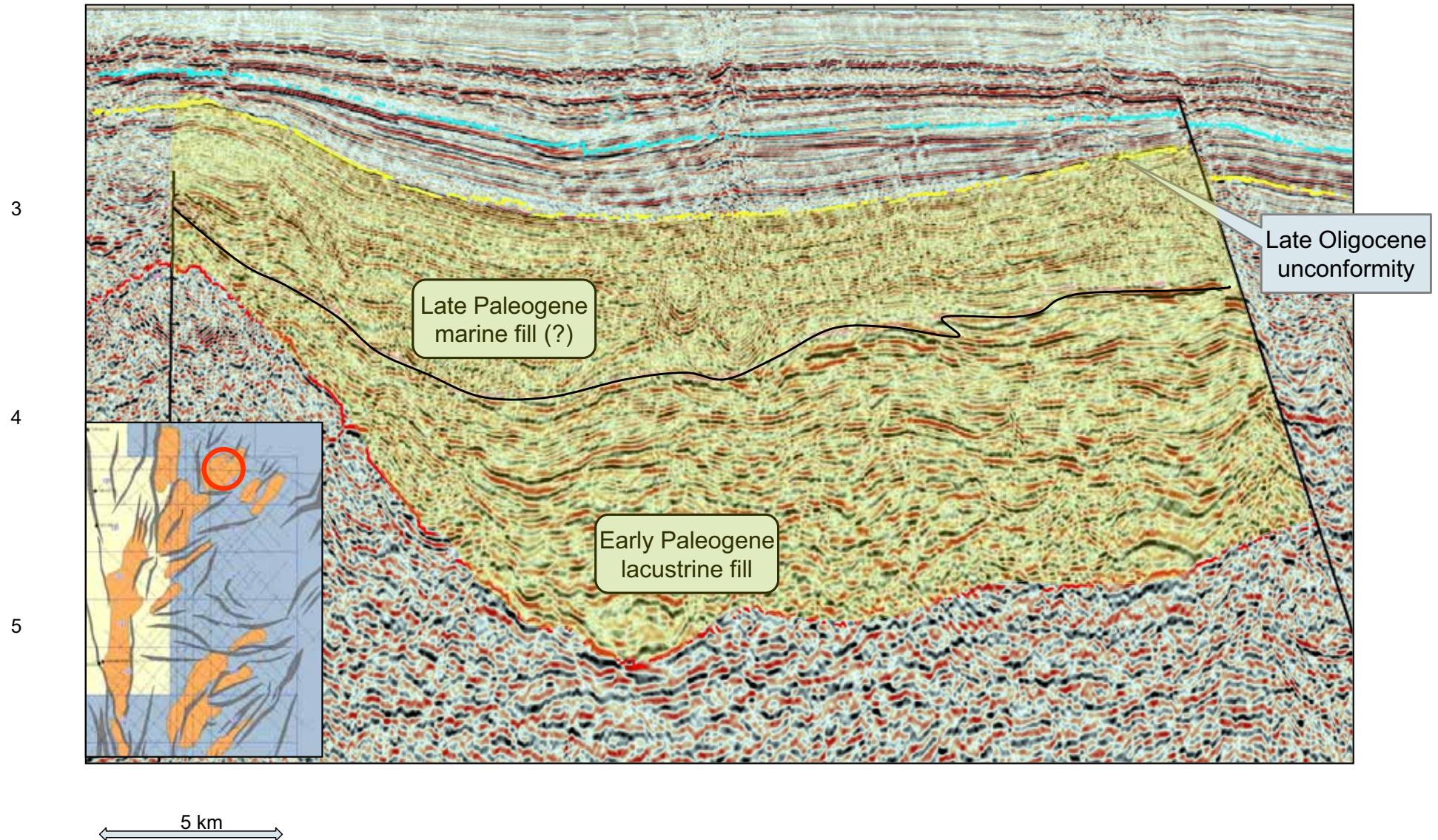


10 km

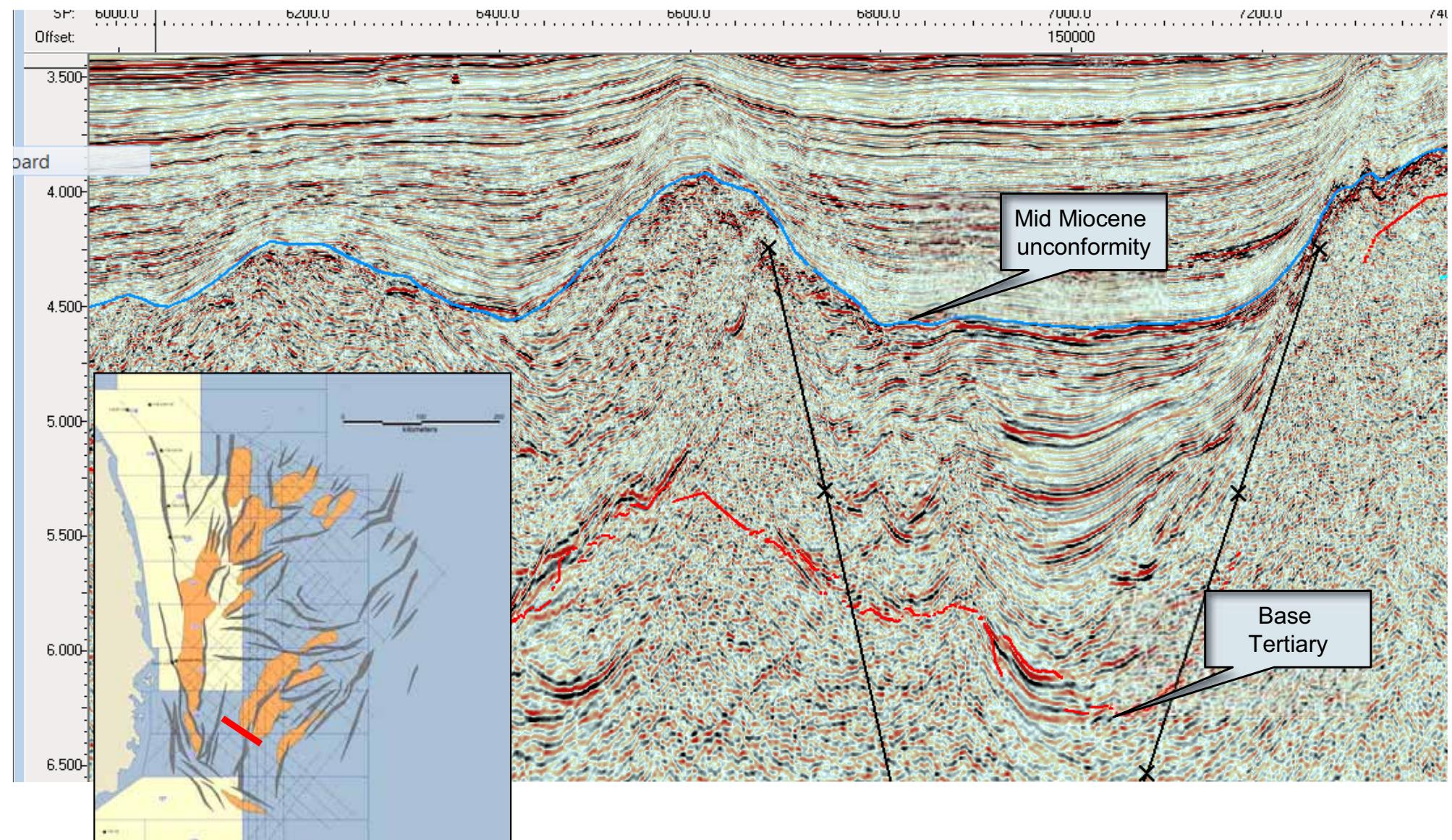
Paleogene syn- rift fill

NW

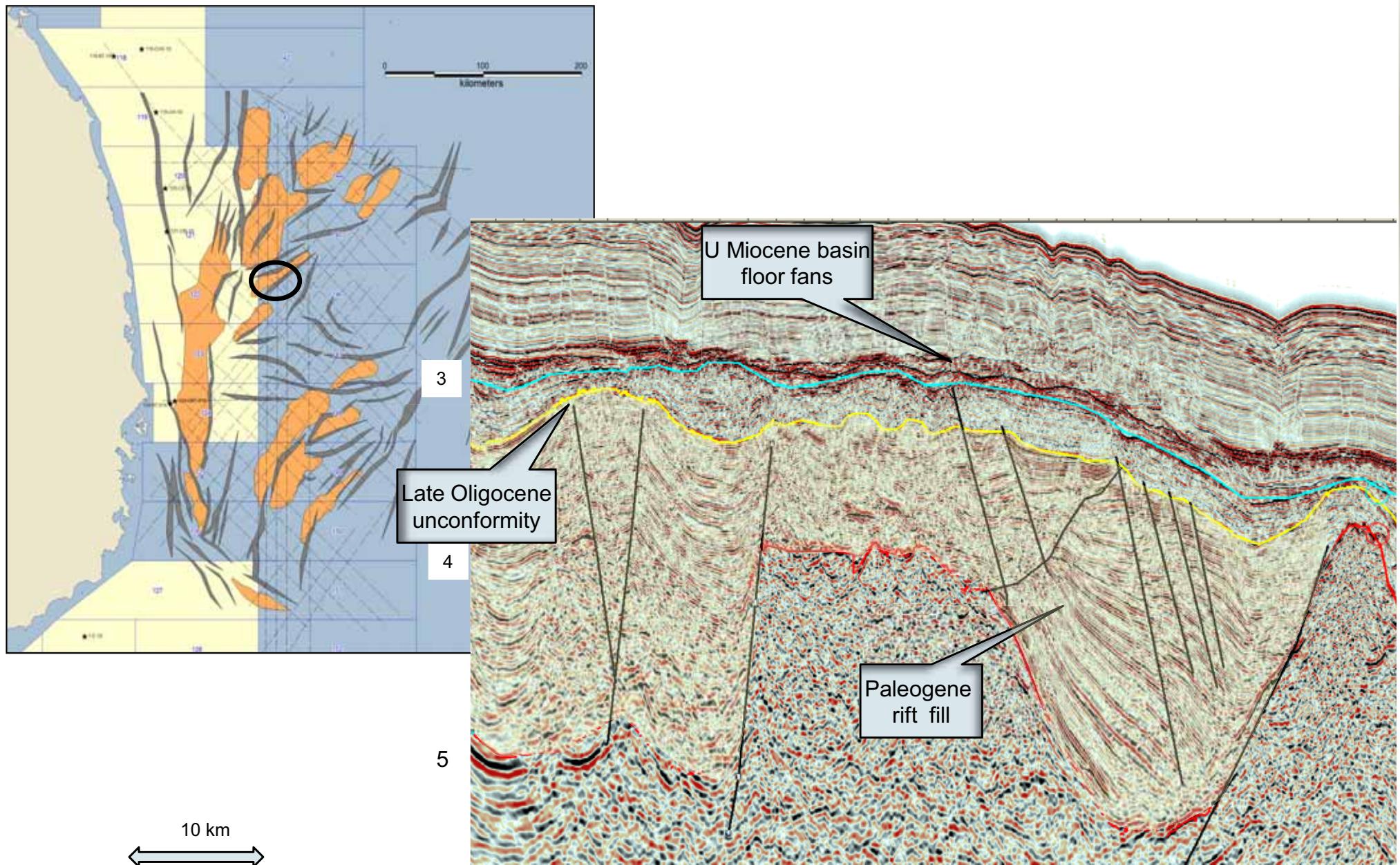
SE



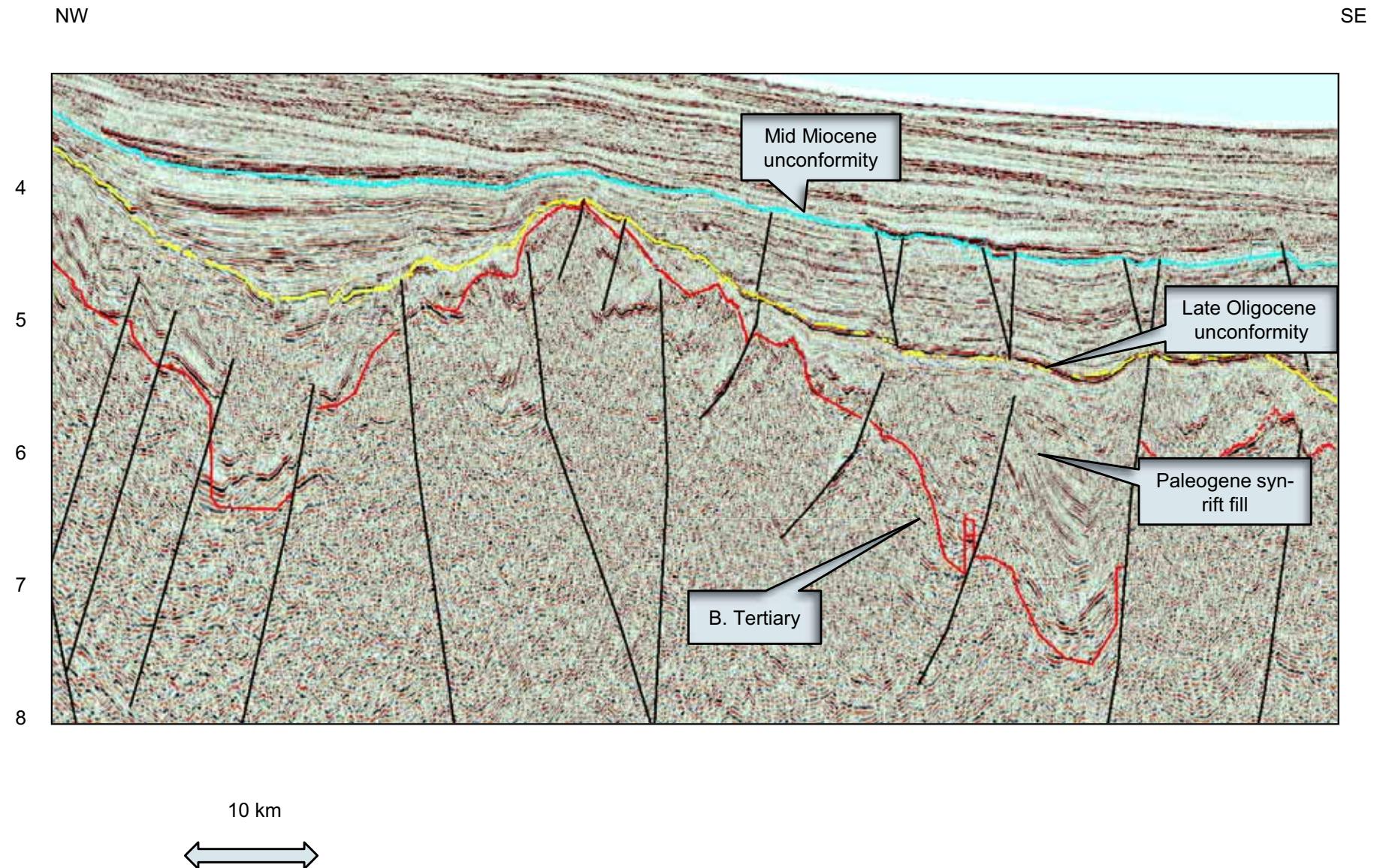
Paleogene syn- rift fill



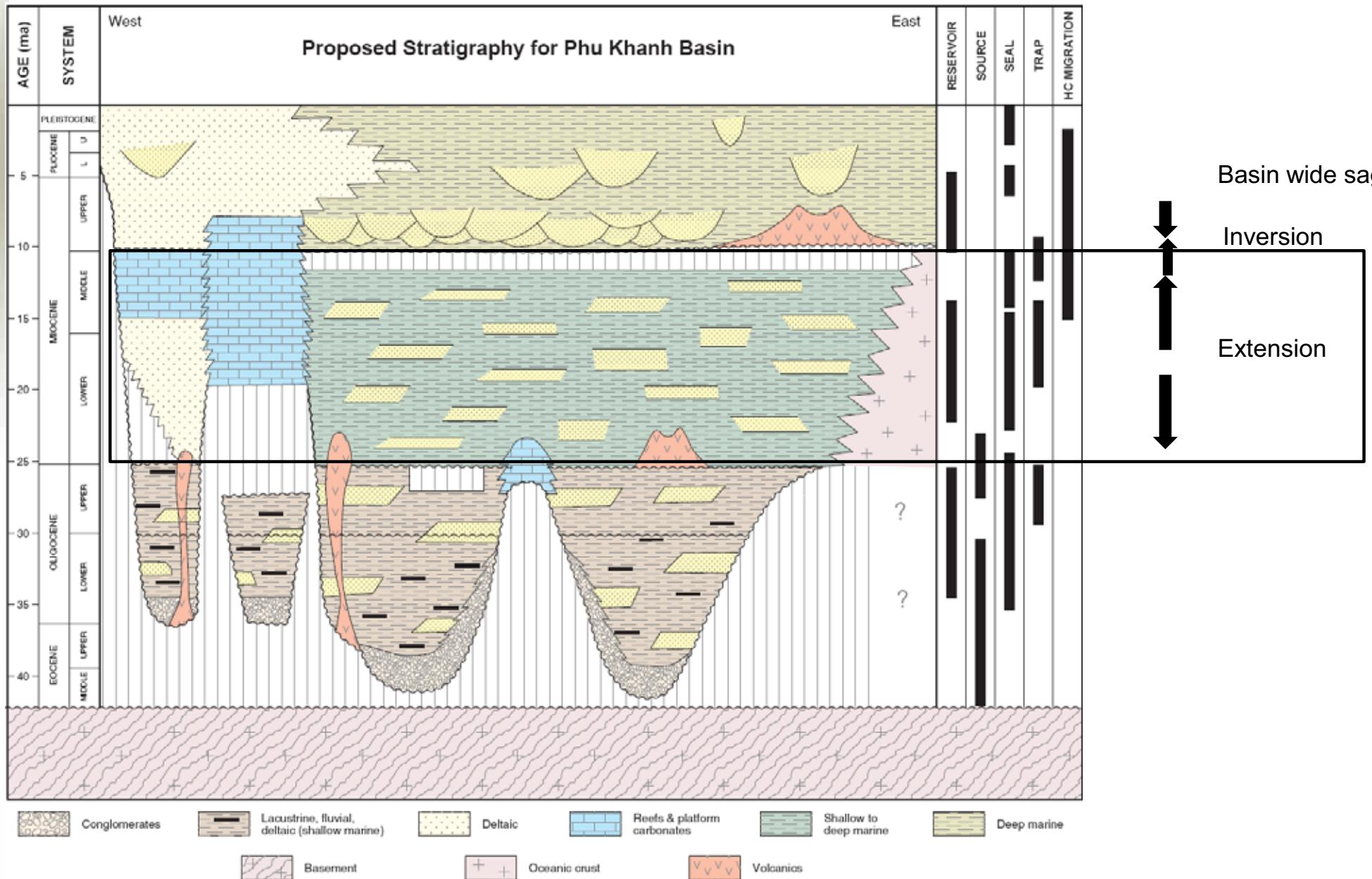
Paleogene syn- rift fill - Late Oligocene Inversion



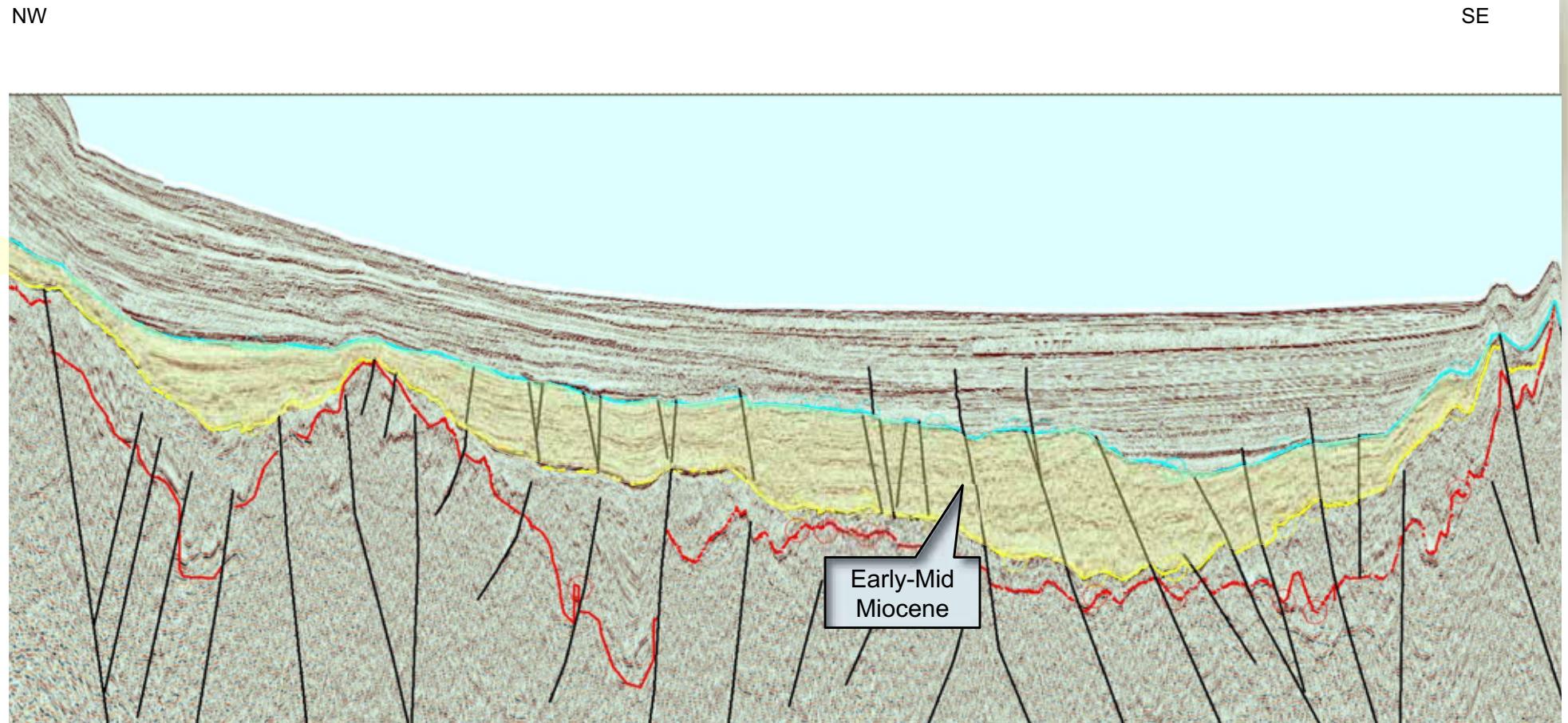
Paleogene syn- rift fill - Late Oligocene Inversion



Proposed strategy for Phu Khanh Basin

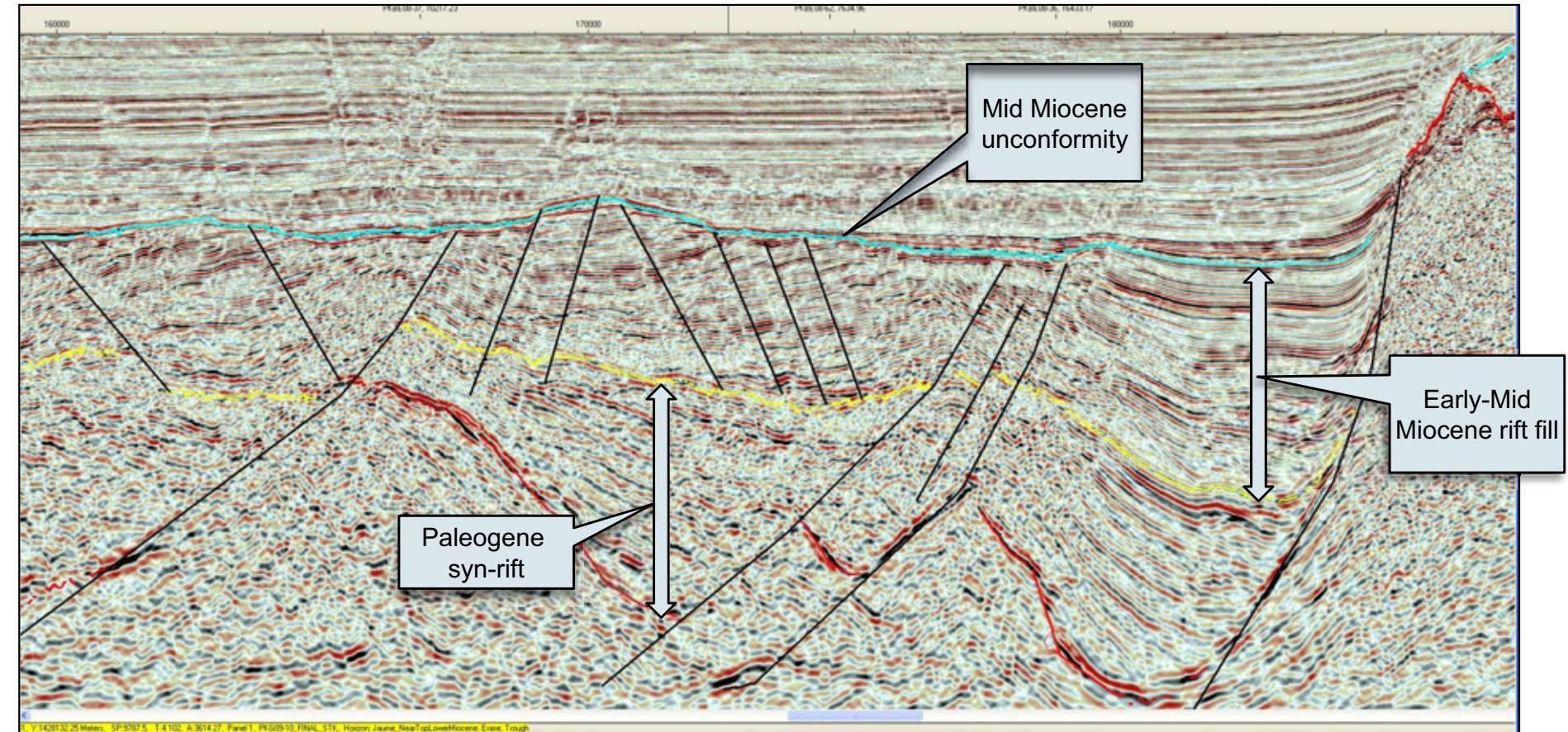


Early-Mid Miocene extension



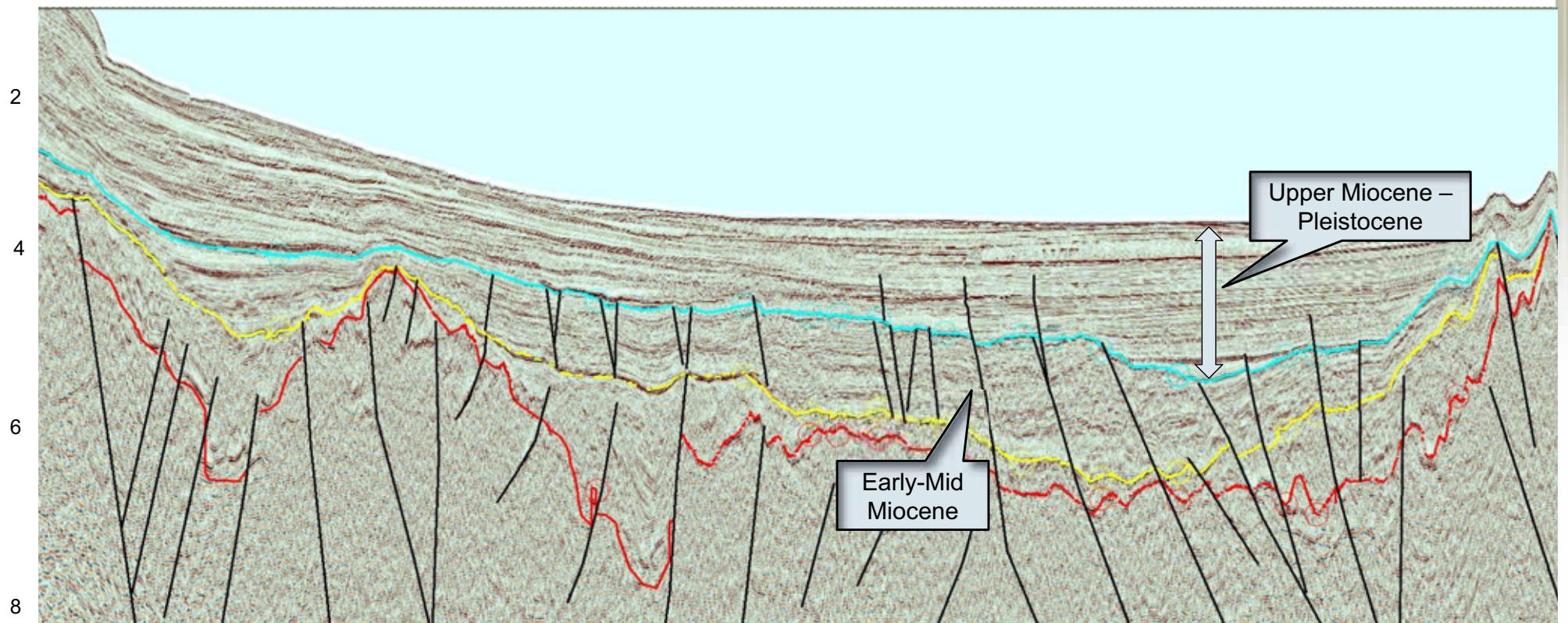
- Early-Mid Miocene; 2.5 - 4 km thick in southern central area
- Same sequence is 3 - 700 m in the northernmost part
- Basin-wide subsidence

Early-Mid Miocene extension and mid (?) Miocene inversion



5 km


Upper Miocene-Pleistocene sag phase

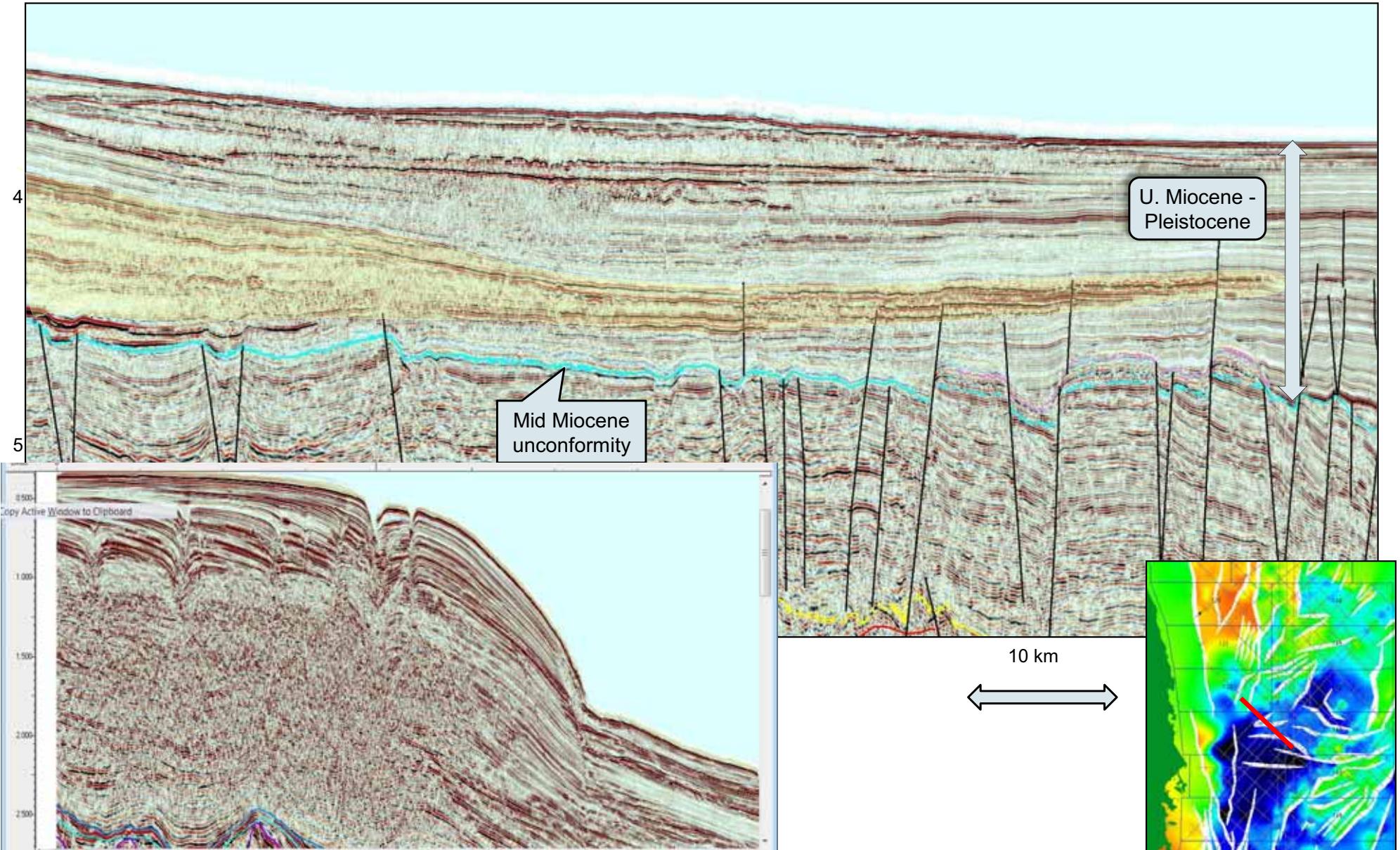


Upper Miocene-Pliocene deep water environment

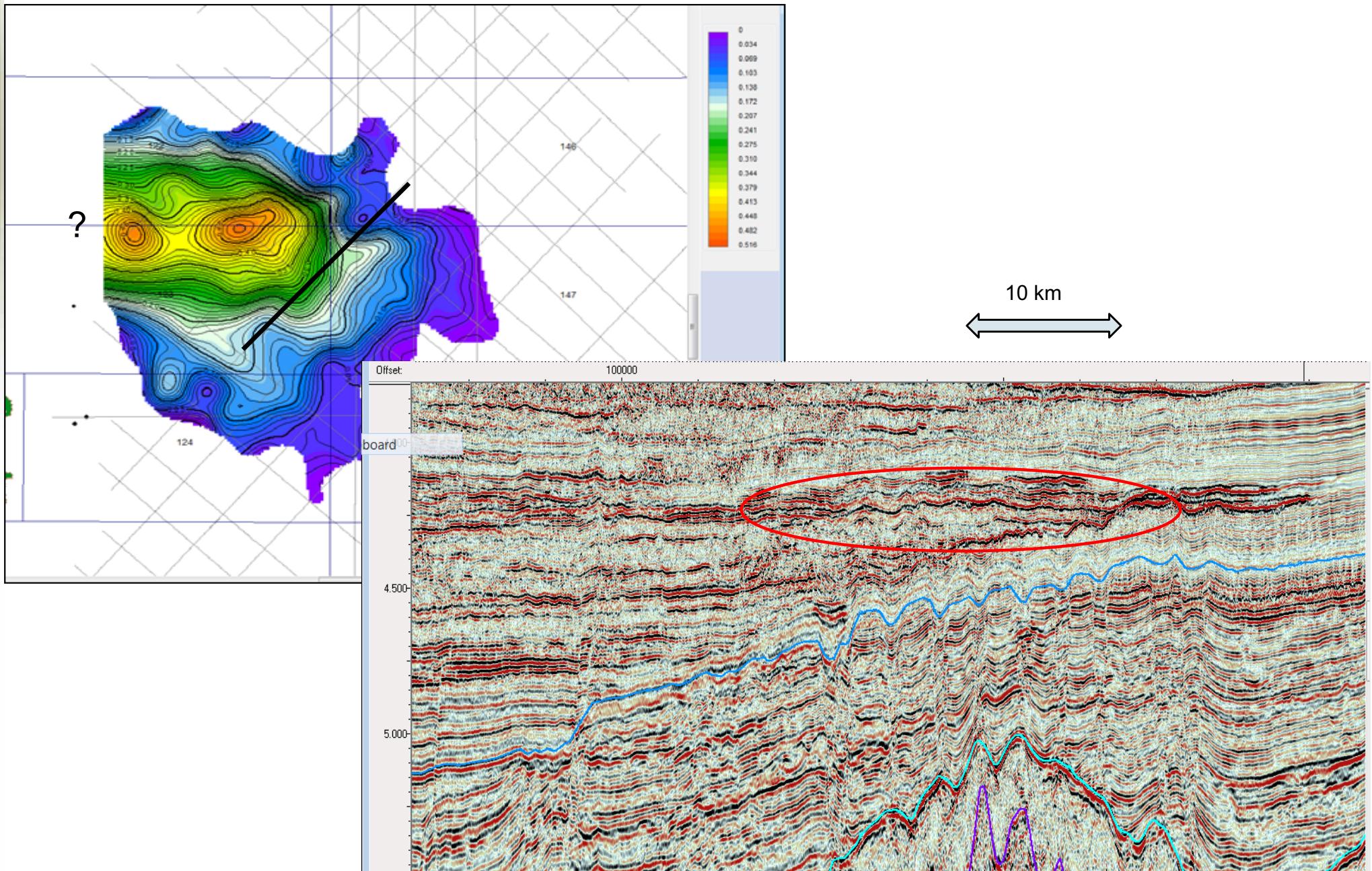
Upper Miocene Basin Floor Fan Complexes/ Contourites (?)

NW

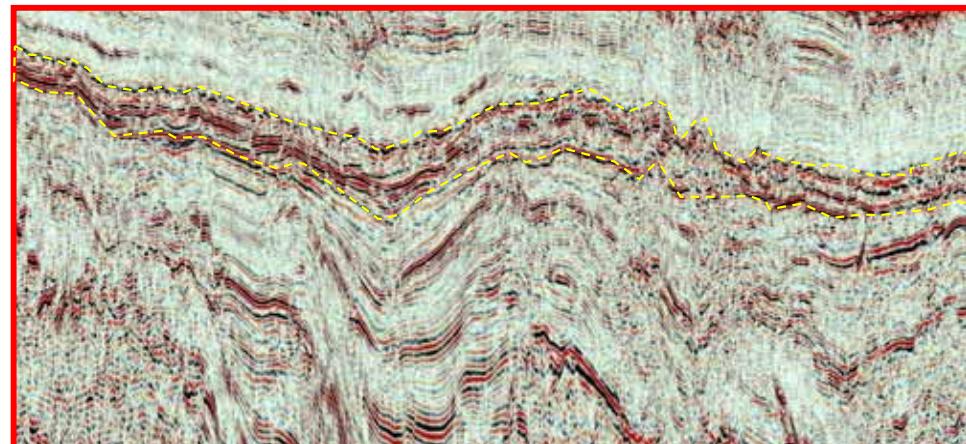
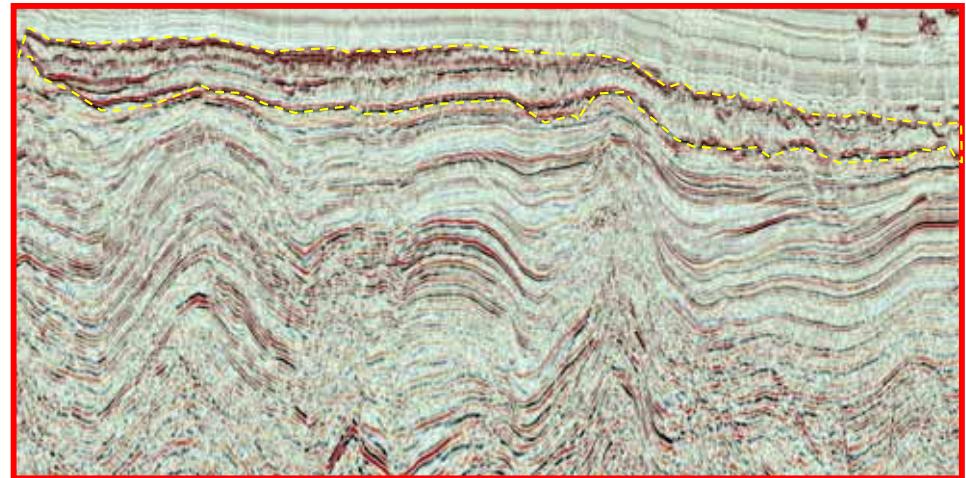
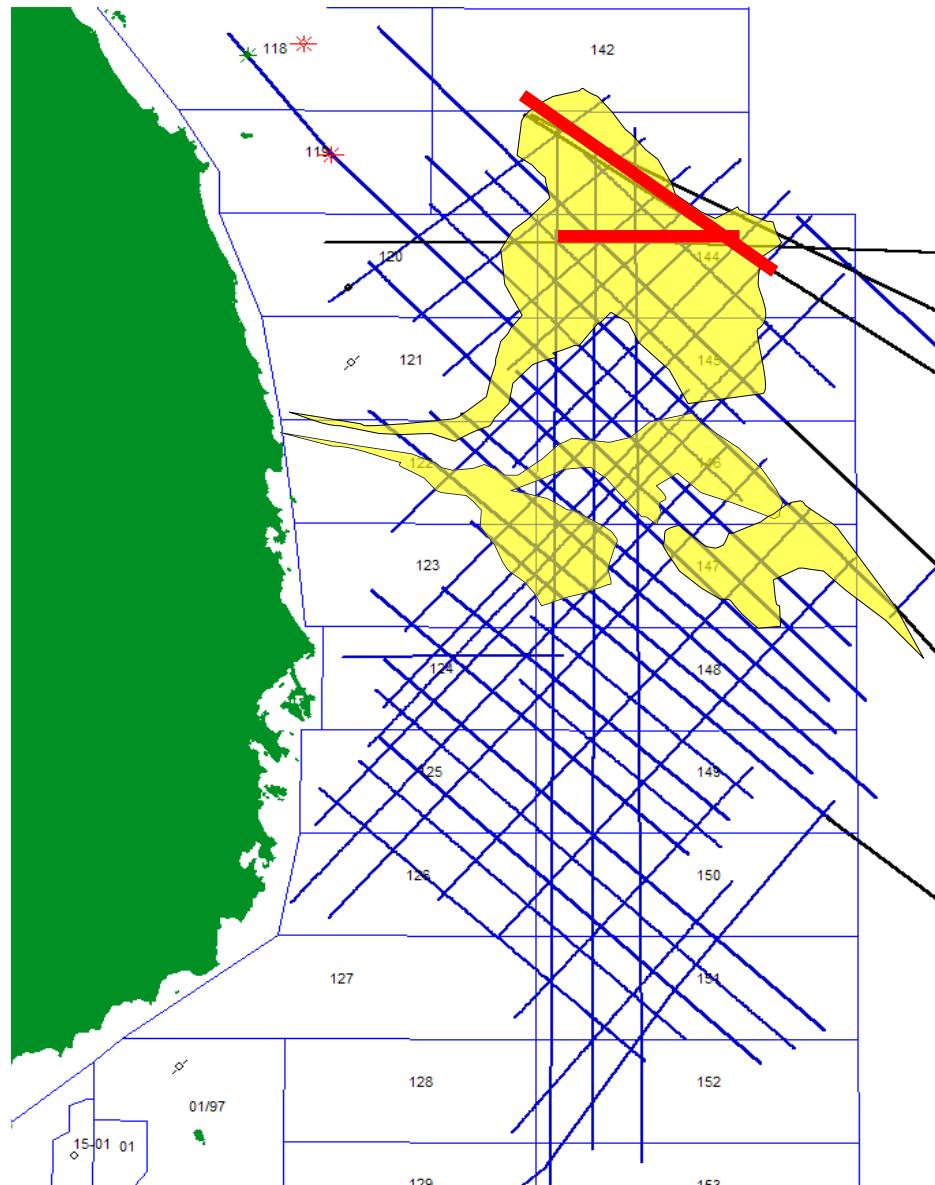
SE



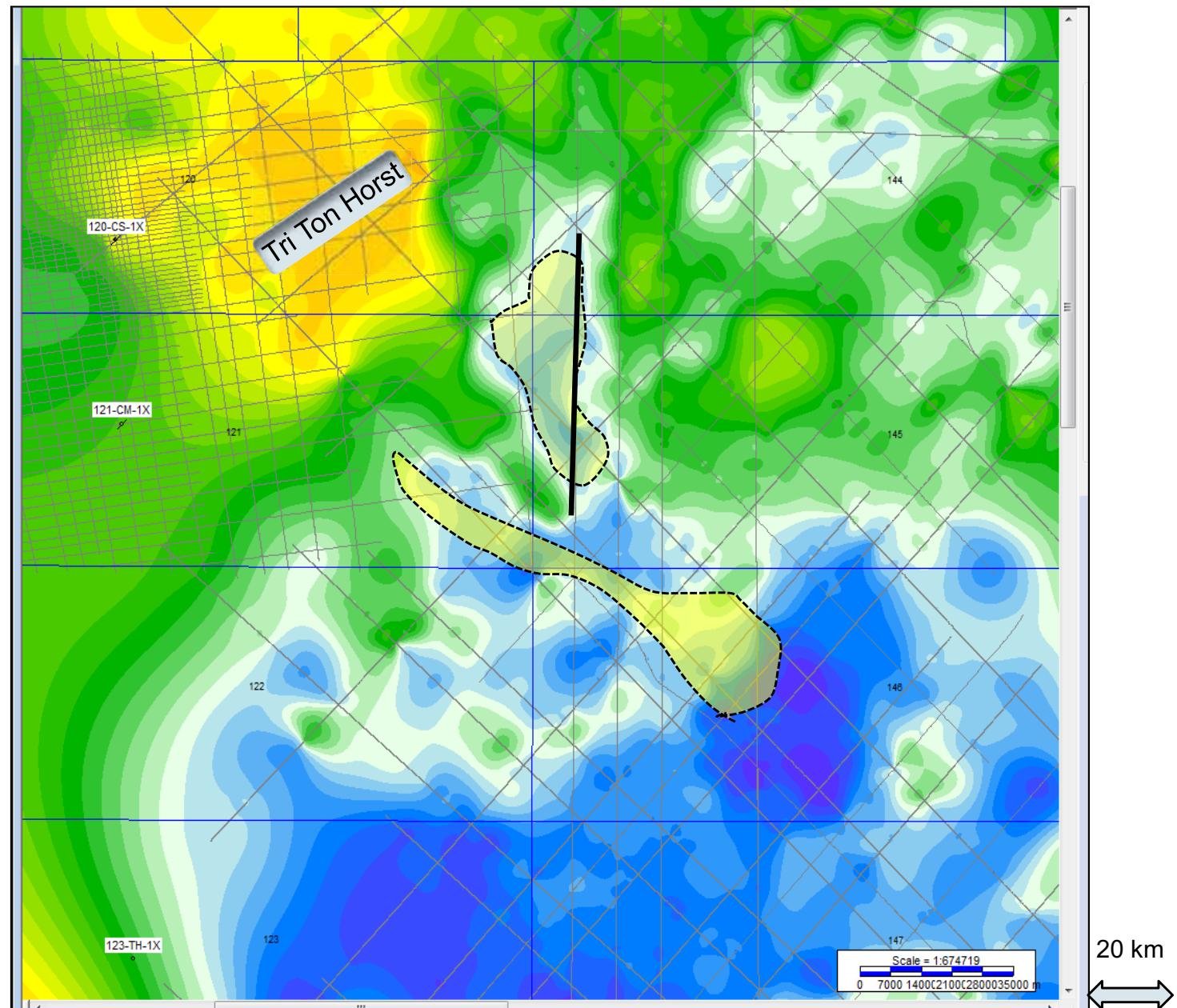
Upper Miocene Basin Floor Fan Complexes/ contourites (?) – isochrone map



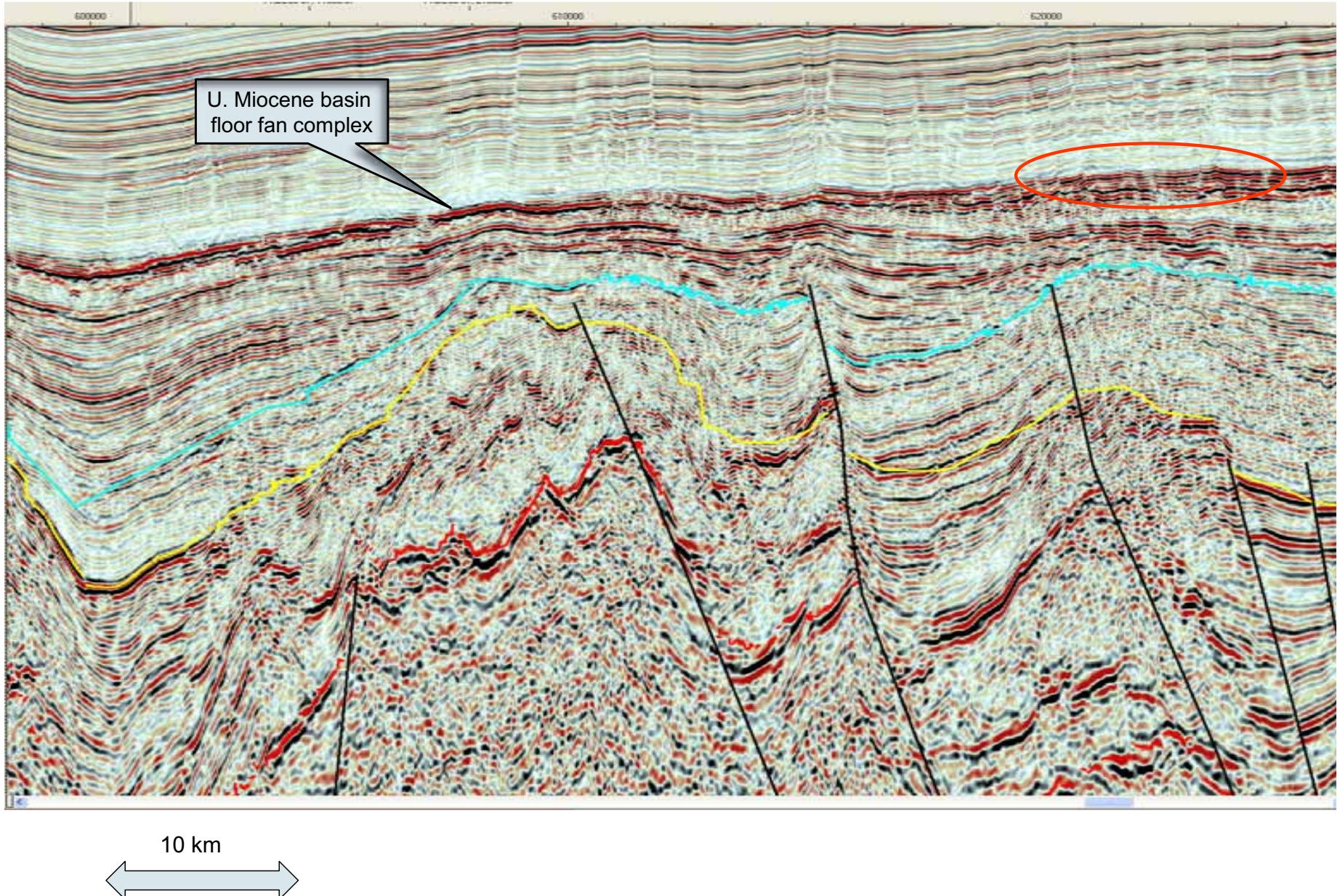
Areal extent and seismic examples of the Upper Miocene basin floor fan complexes



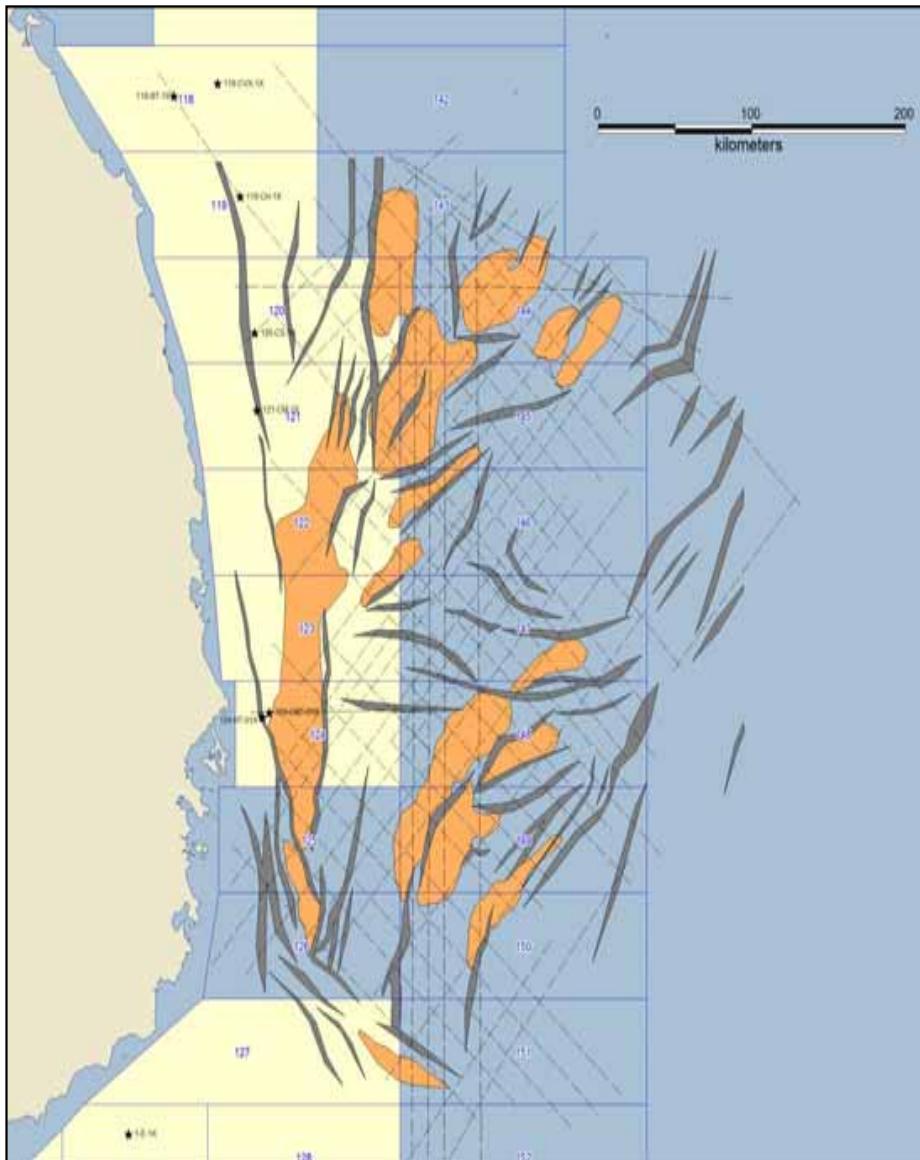
Phu Khanh – example of Upper Miocene confined slope fan complexes northern part of area



Example of slope fan complex NW flank of PK Basin



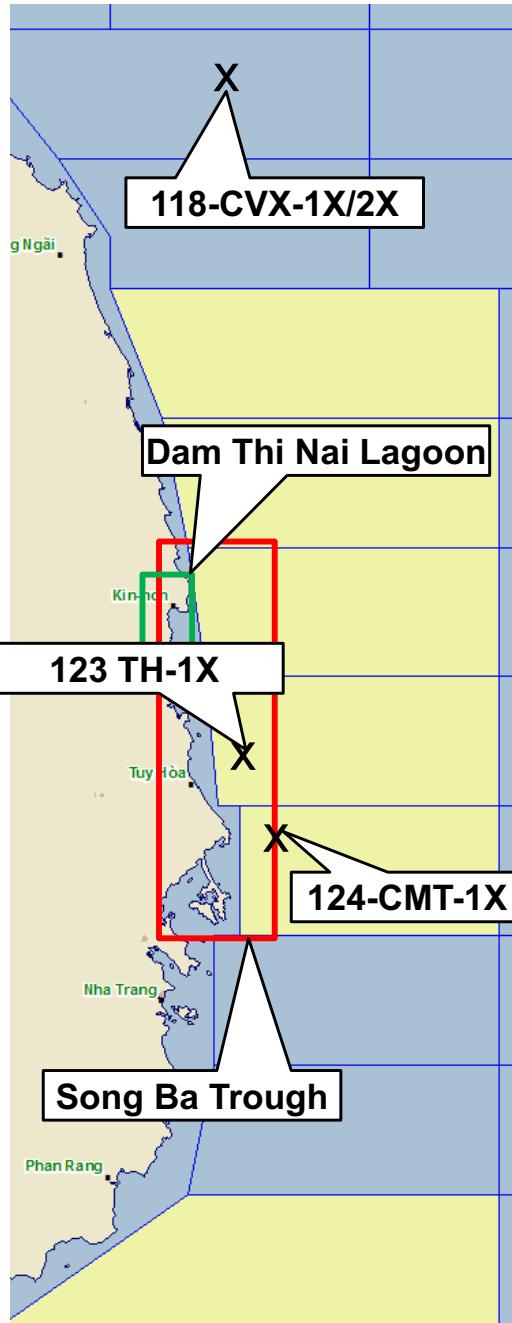
Phu Khanh Basin – Source Rocks



Potential source rocks;

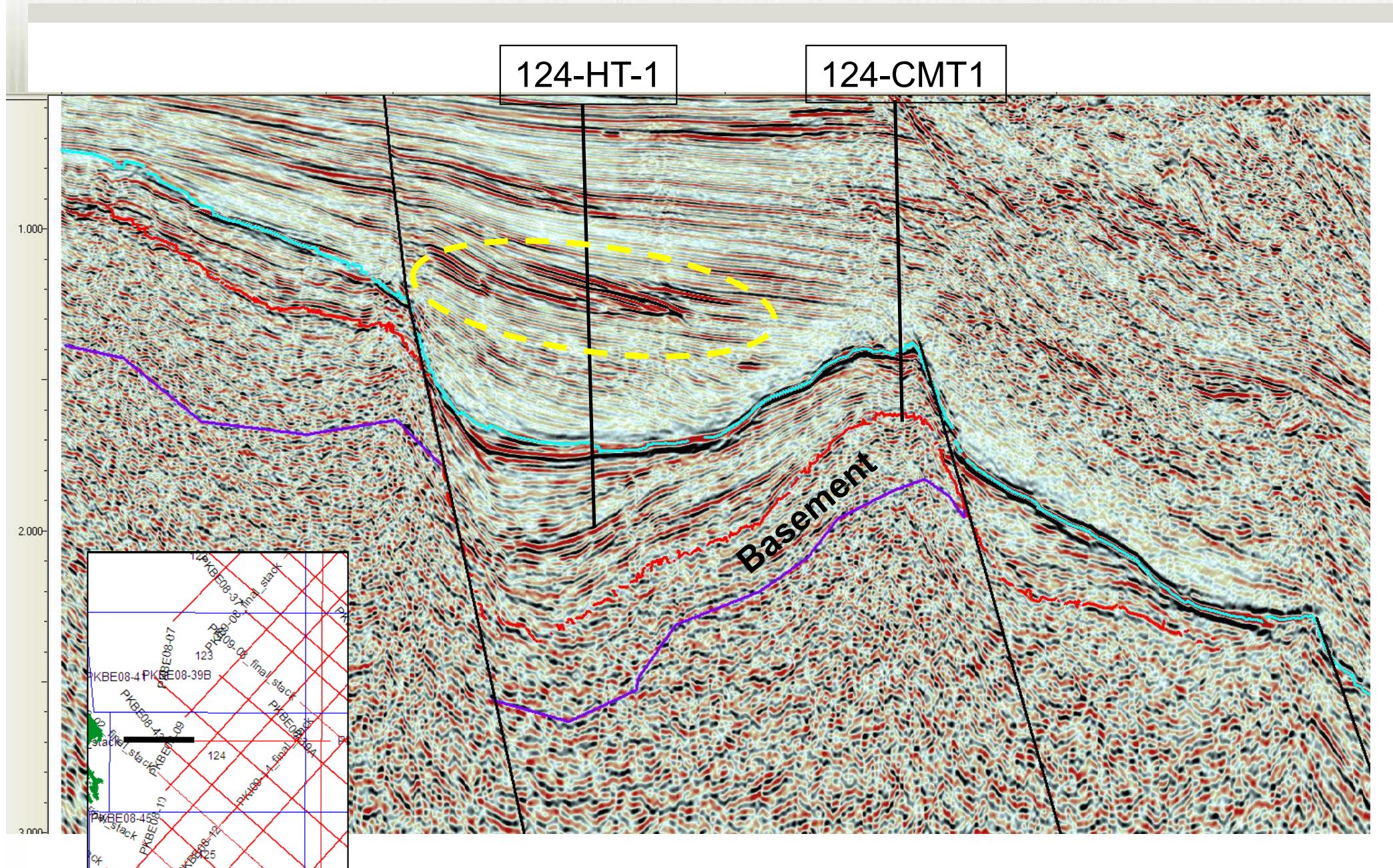
- ?Oligocene syn-rift fill, up-to 3 km+ thick
- Early Miocene coaly/shallow marine shales

Source Rocks



- **123-TH – 1X (Santos)**, High CO₂, with oil shows
- **124-CMT-1X** – ,48 m oil column, sourced from lacustrine rocks
- **Dam Thi Nai Lagoon** – Oil seepages in basement generated from a Tertiary marine marl source, migration from PK basin
- **118-CVX-1X** – 30m thick Oligocene shales with up to 6 % TOC and HI=440. **118-CVX-2X (XoM)** – Reported 3-5 tcfg, with 25% CO₂
- **Song Ba Trough**- Onshore lacustrine mudstone analogues – TOC of 4 to 20% and HI of 300 to 700 kerogen type I/II
- **Conclusion** - Lacustrine mudstones and coals provide excellent potential source rocks for oil and gas generation in the region. These source rocks are interpreted to be abundant in the Palaeogene syn-rift of the Phu Khanh Basin

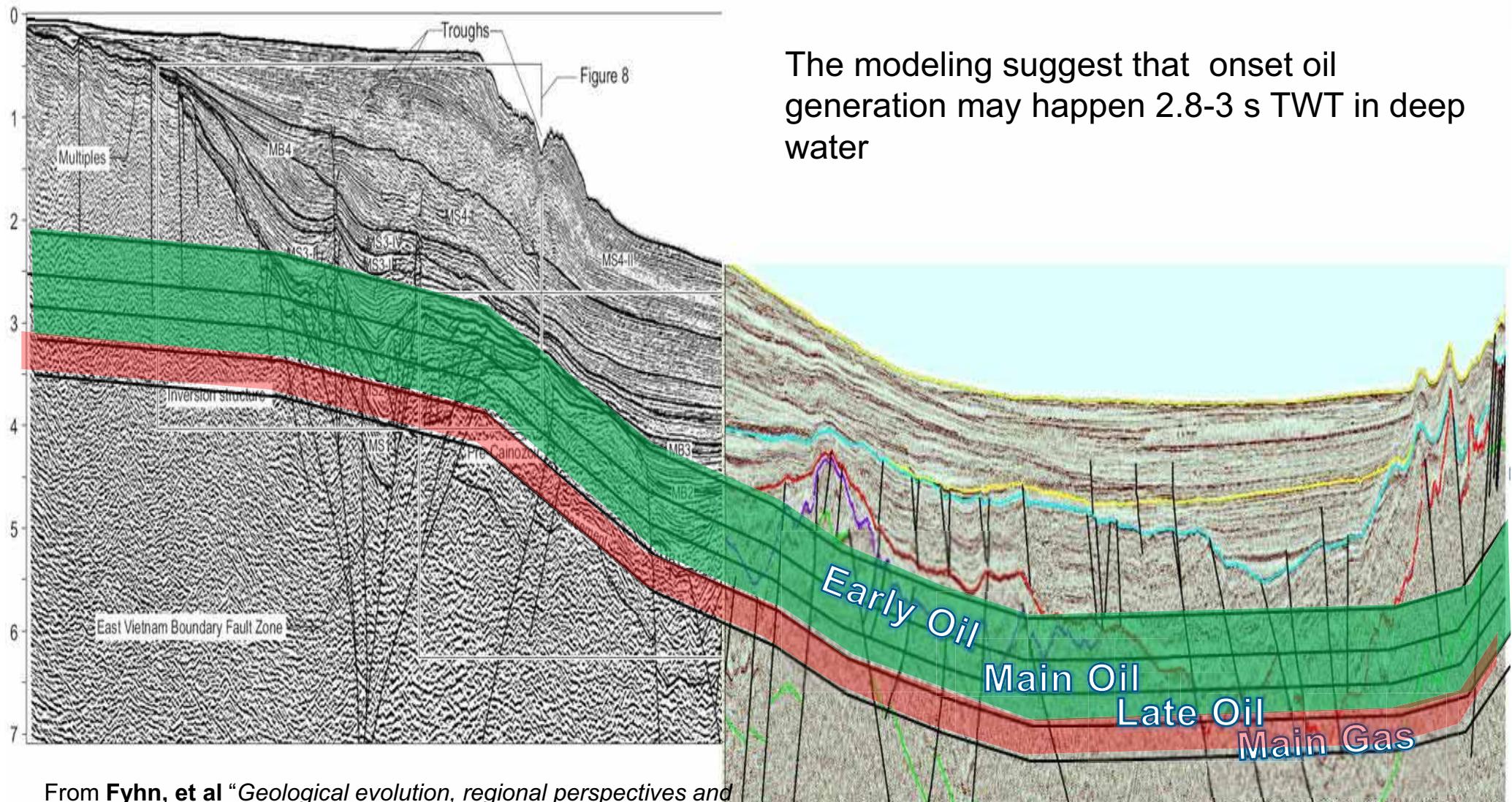
PK -09, BI 124 “Oil discovery” – only real test of Phu Khanh Basin



HC Modeling

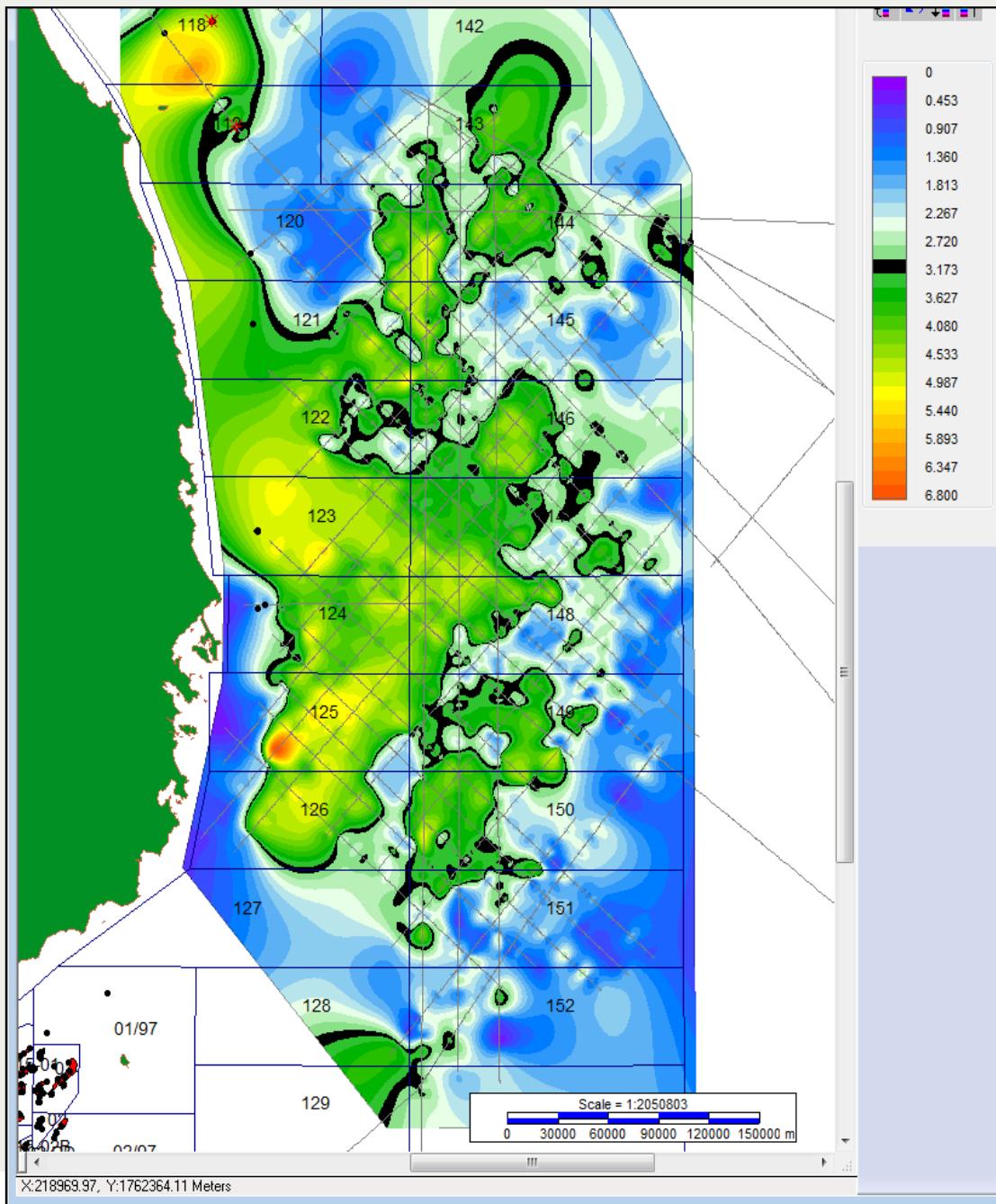
NW

SE



From Fyhn, et al "Geological evolution, regional perspectives and hydrocarbon potential of the northwest Phu Khanh Basin, offshore Central Vietnam"

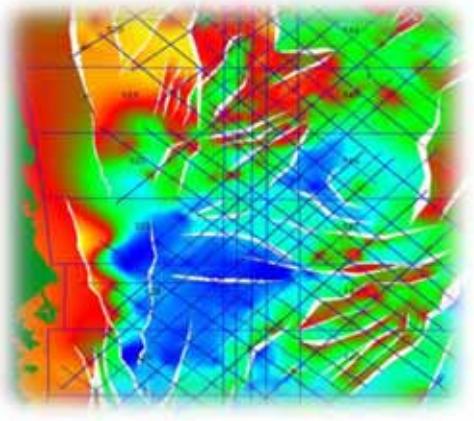
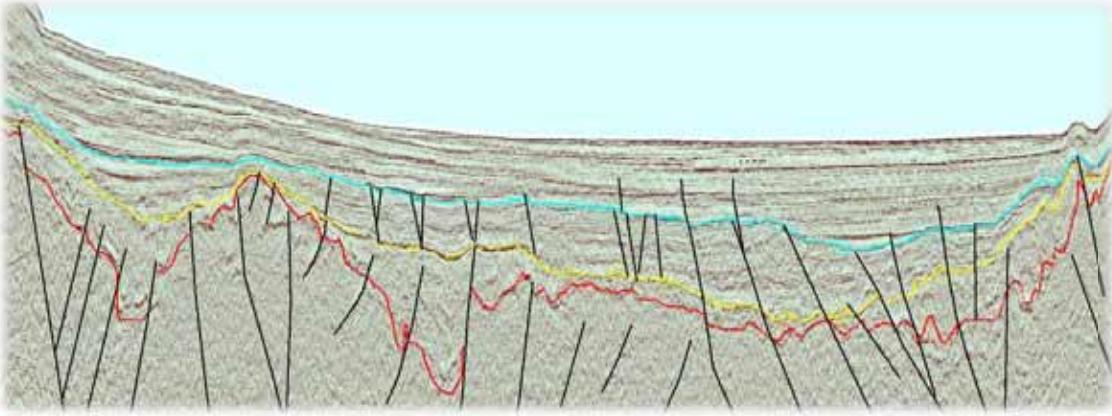
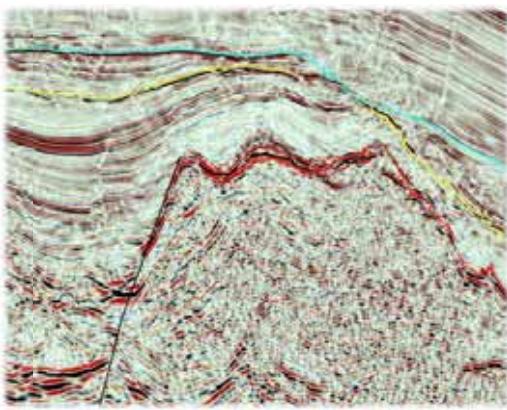
Phu Khanh – areas of possible mature source rocks



B. Tertiary – water depth isochrone, with 3sec contour

Phu Khanh Basin - Examples of leads

- Fan leads in stratigraphic/structural traps
- Structural leads Early-Mid Miocene and Oligocene clastic reservoir
- Carbonate reservoirs
- Basement/"buried hill" leads



Phu Khanh – Fan play reservoirs



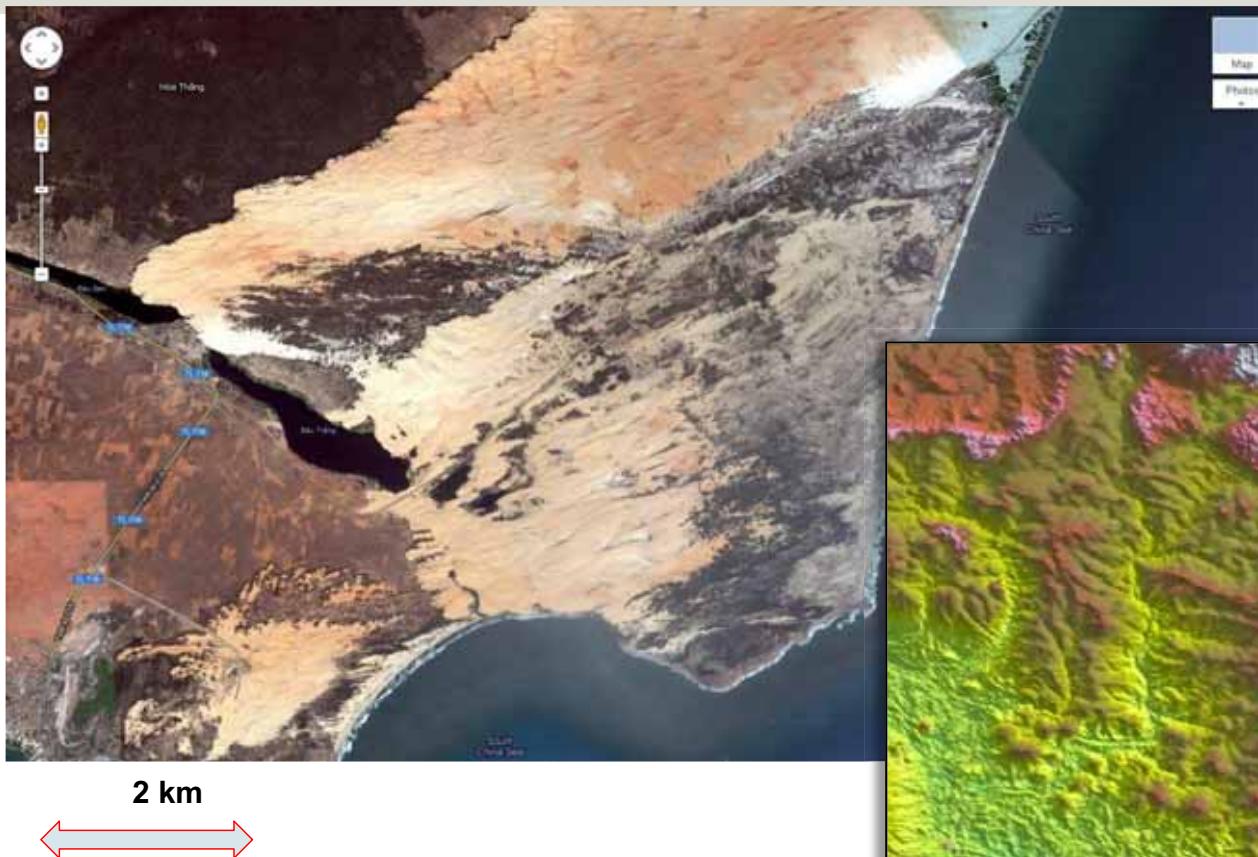
Central area/southern area – high chance of sand

1. Extensive sand dunes in coastal areas
2. Well 124 – 2X, good sands in Upper Miocene shelf setting

Northern area

1. Risk of redeposited carbonates

Phu Khanh – Fan play reservoirs

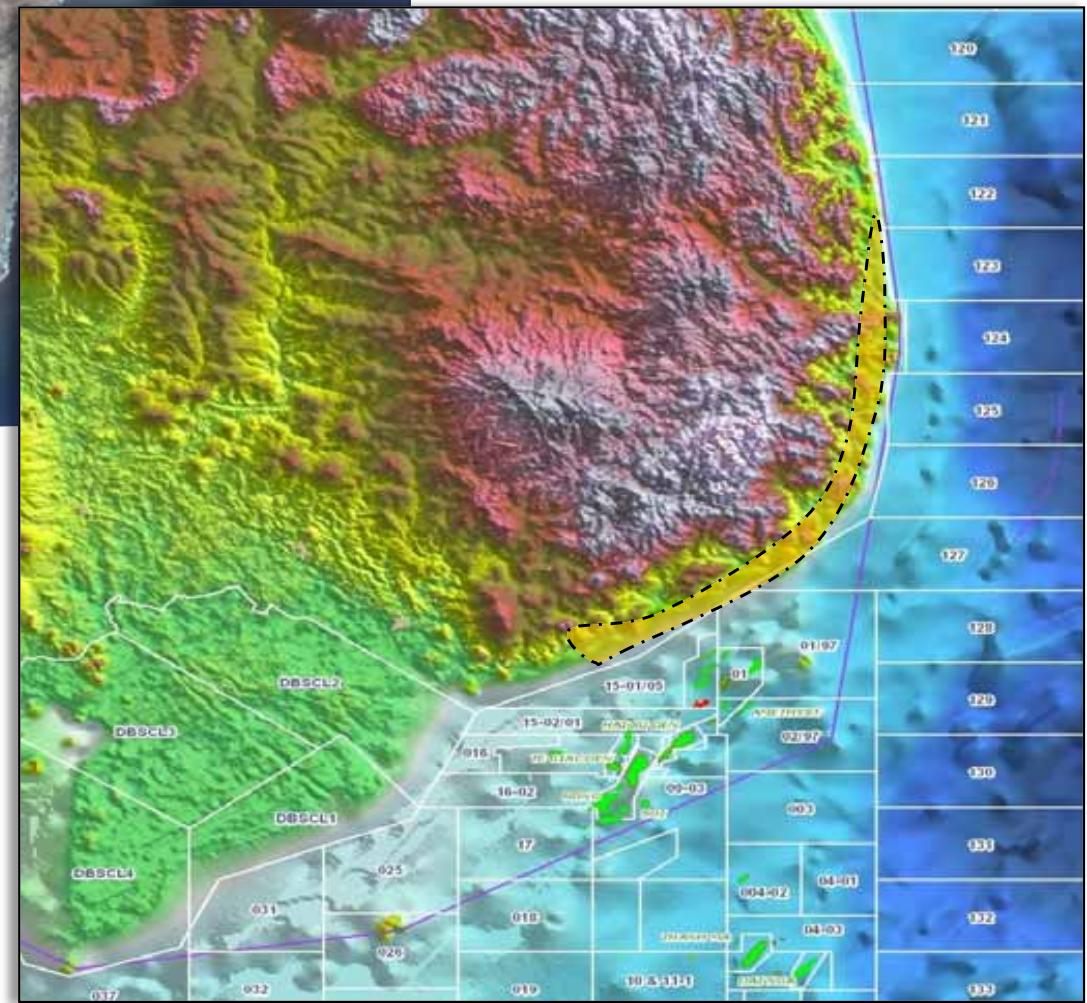


Central area/southern area – high chance of sand

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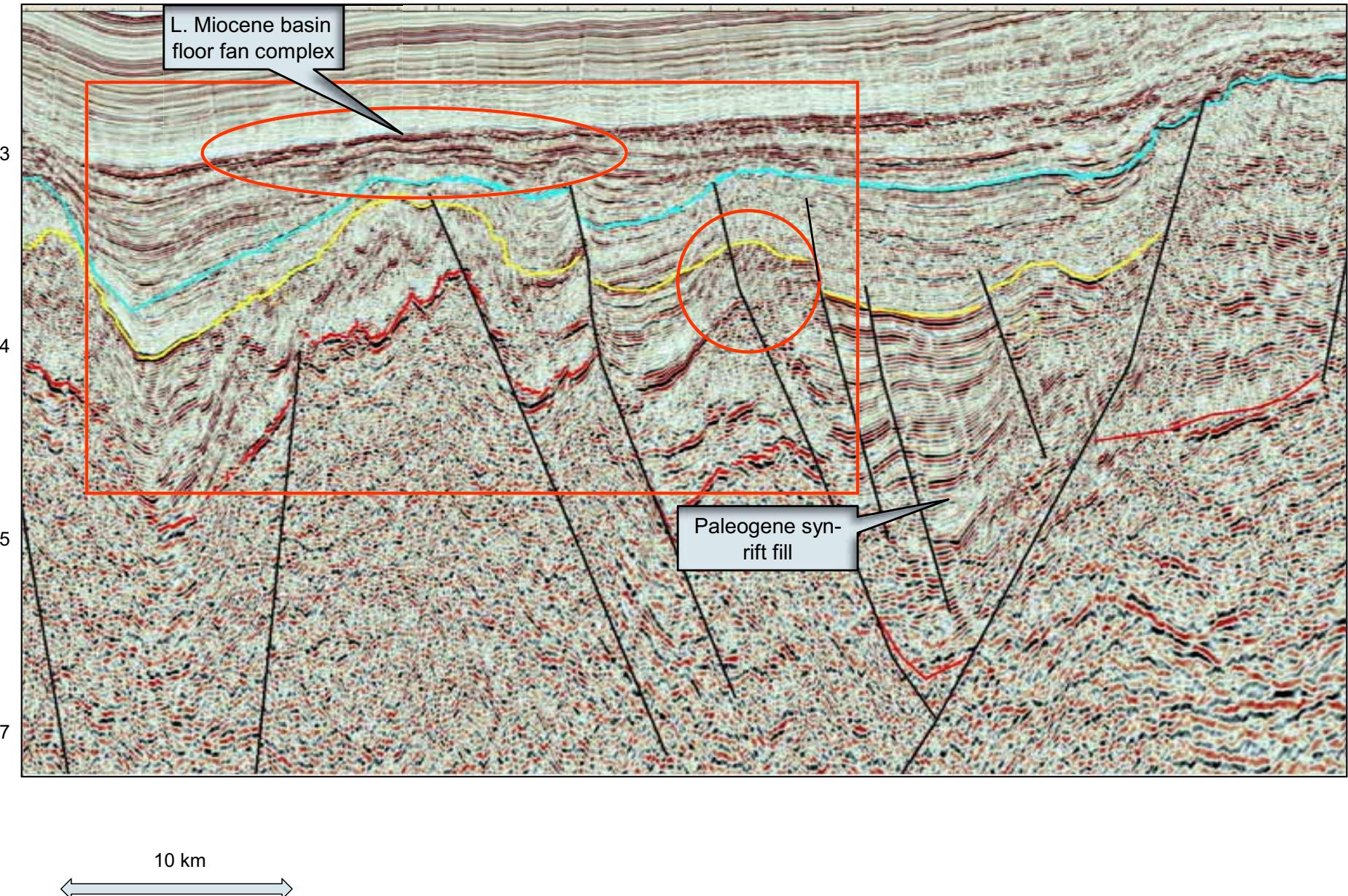
Northern area

1. Risk of redeposited carbonates

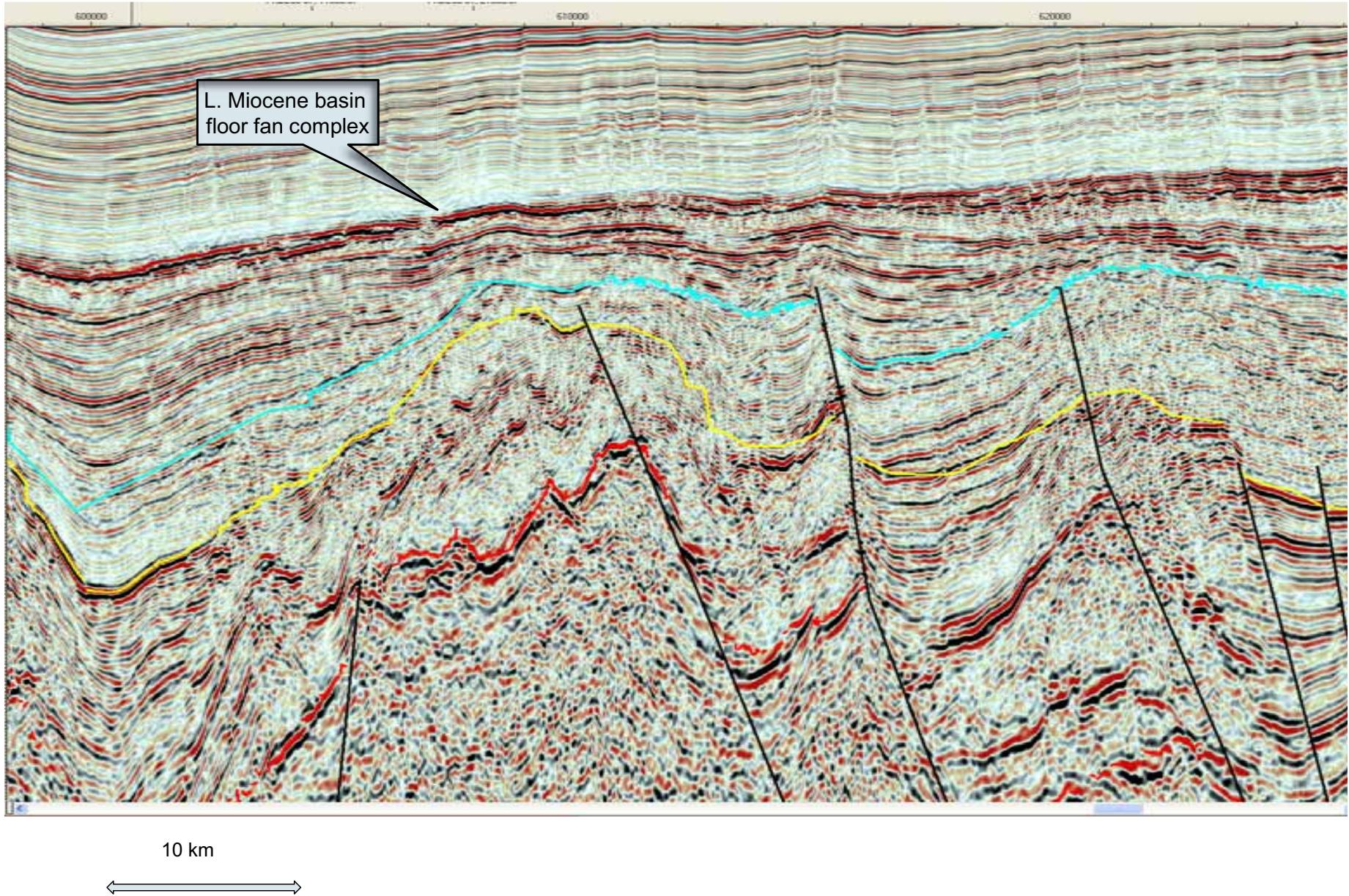


Example of leads along NW flank of PK Basin

Late Miocene sands in distal basin floor fans in structural/stratigraphic traps

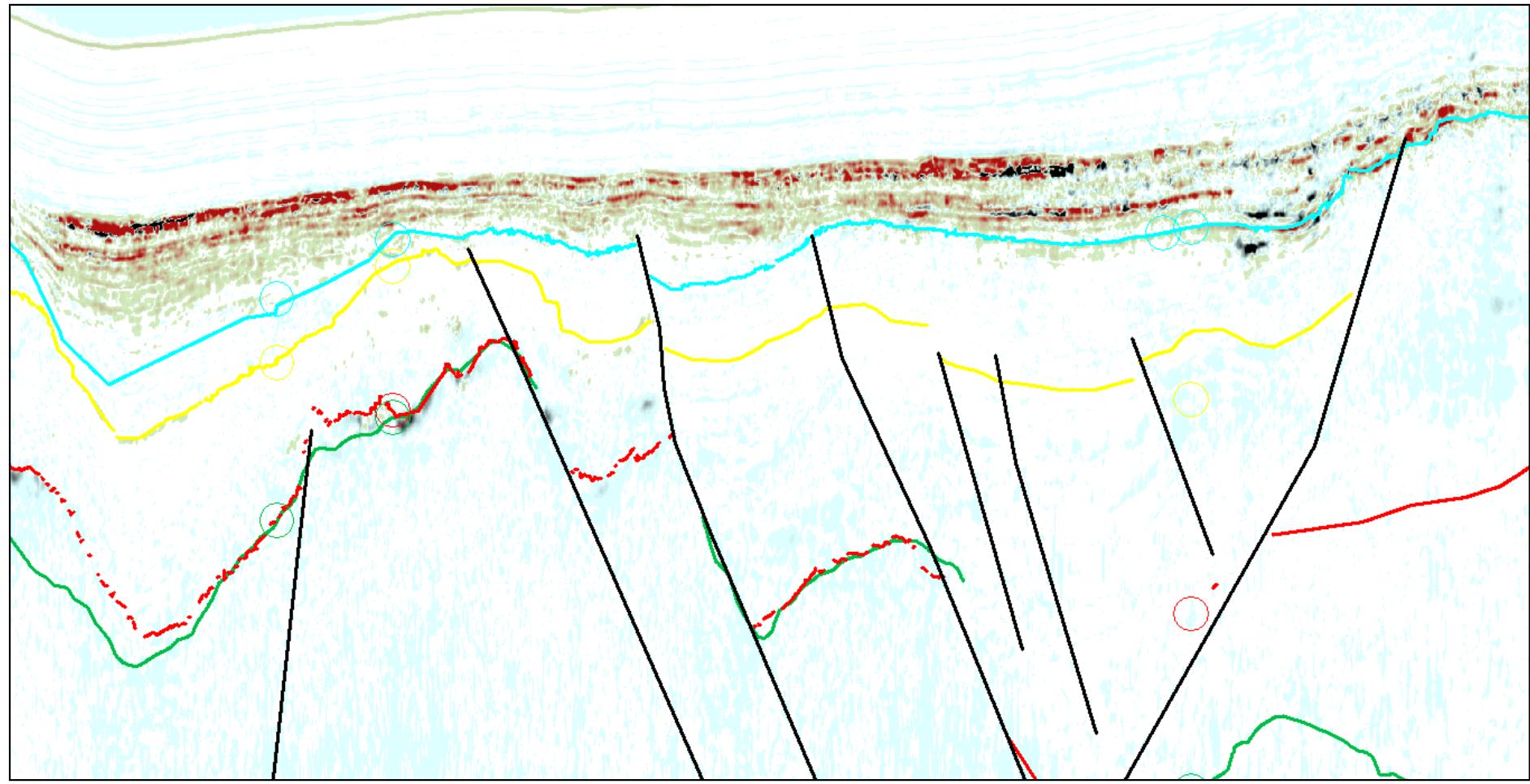


Example of leads along NW flank of PK Basin



Example of leads along NW flank of PK Basin

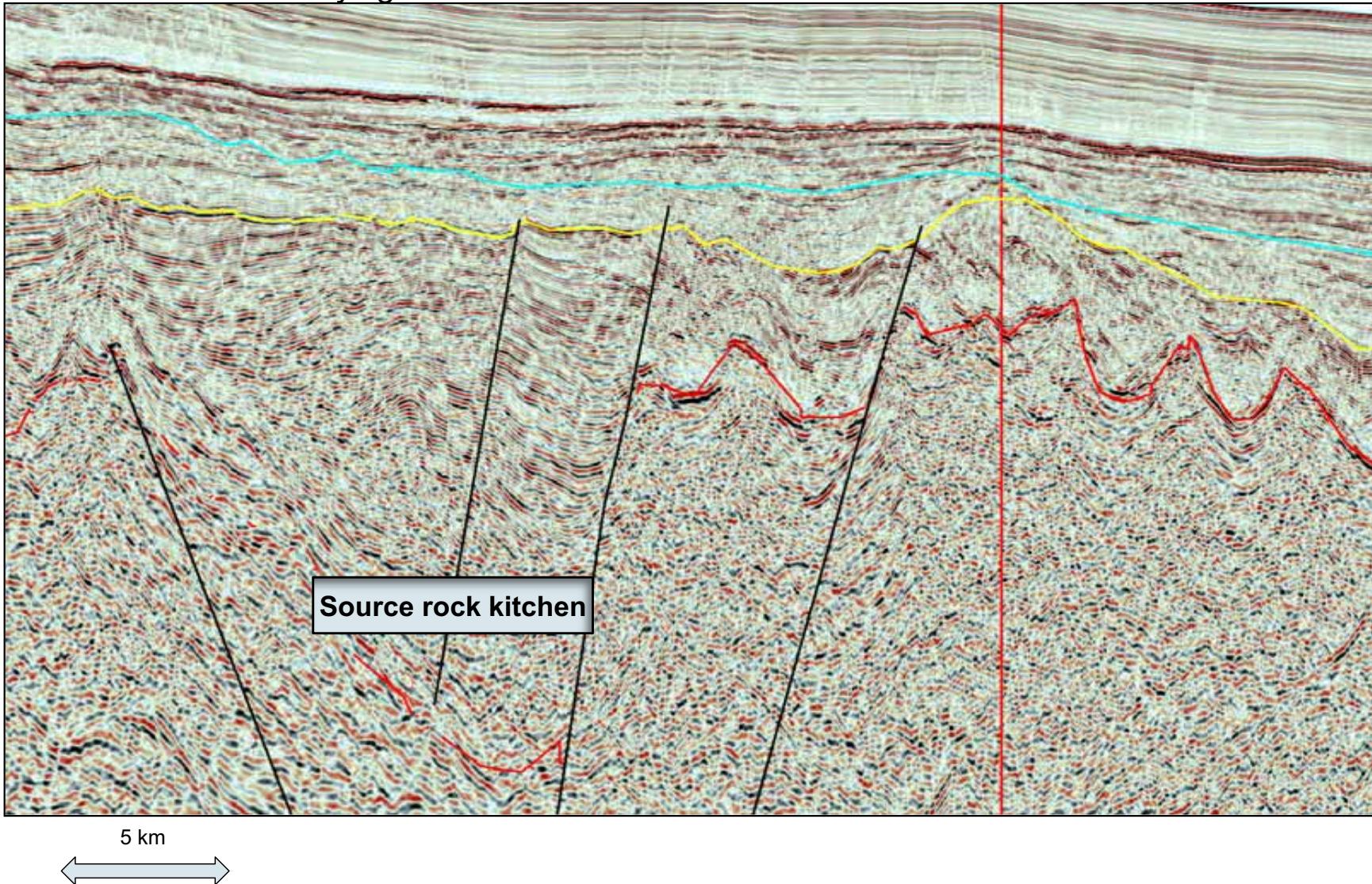
Late Miocene sands in distal basin floor fans in structural/stratigraphic traps



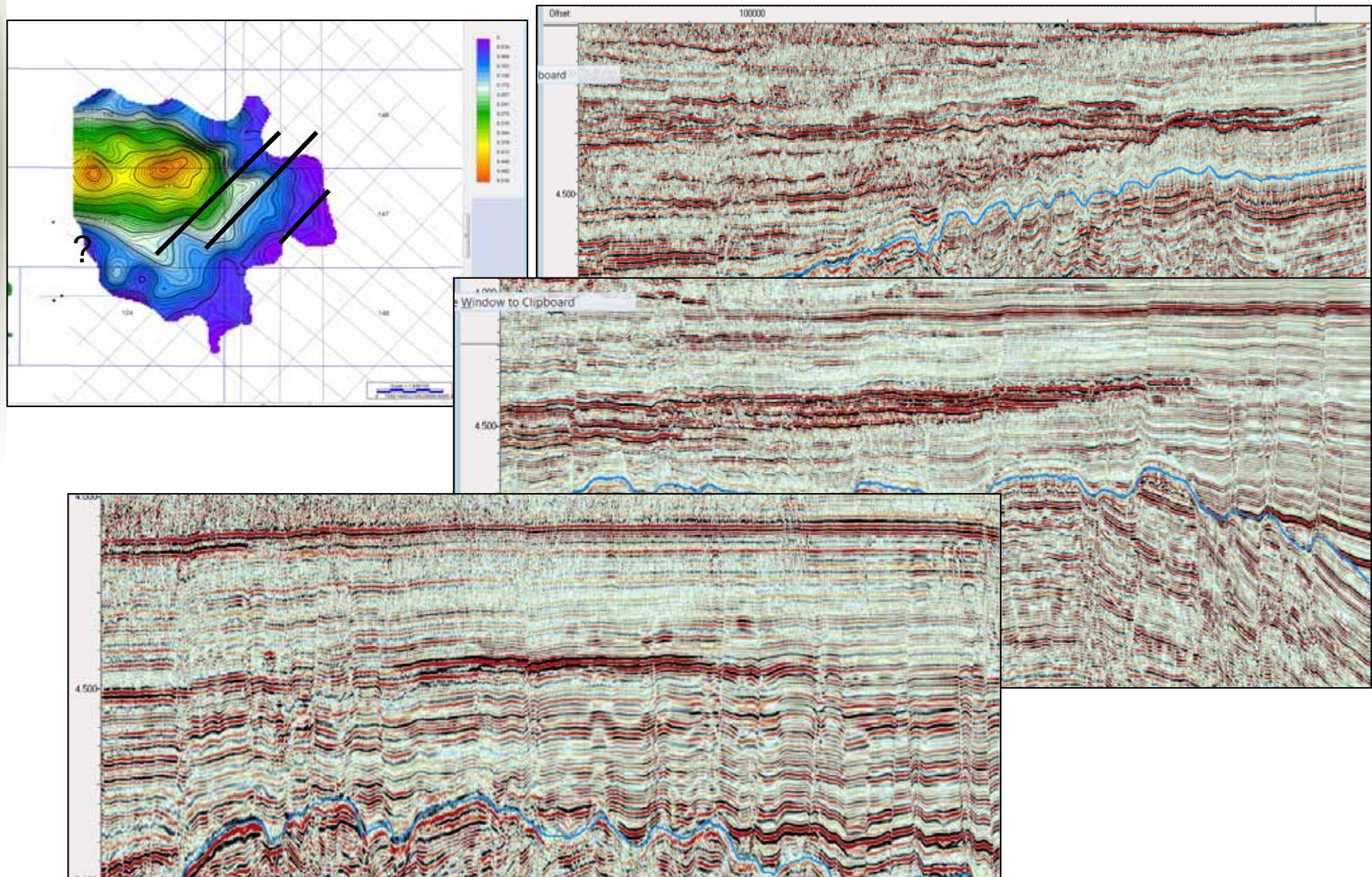
Far - nears

Cross line from previous lead example

1. Late Miocene sands in distal basin floor fans in structural/stratigraphic traps
2. Underlying structural leads
3. Underlying source kitchen

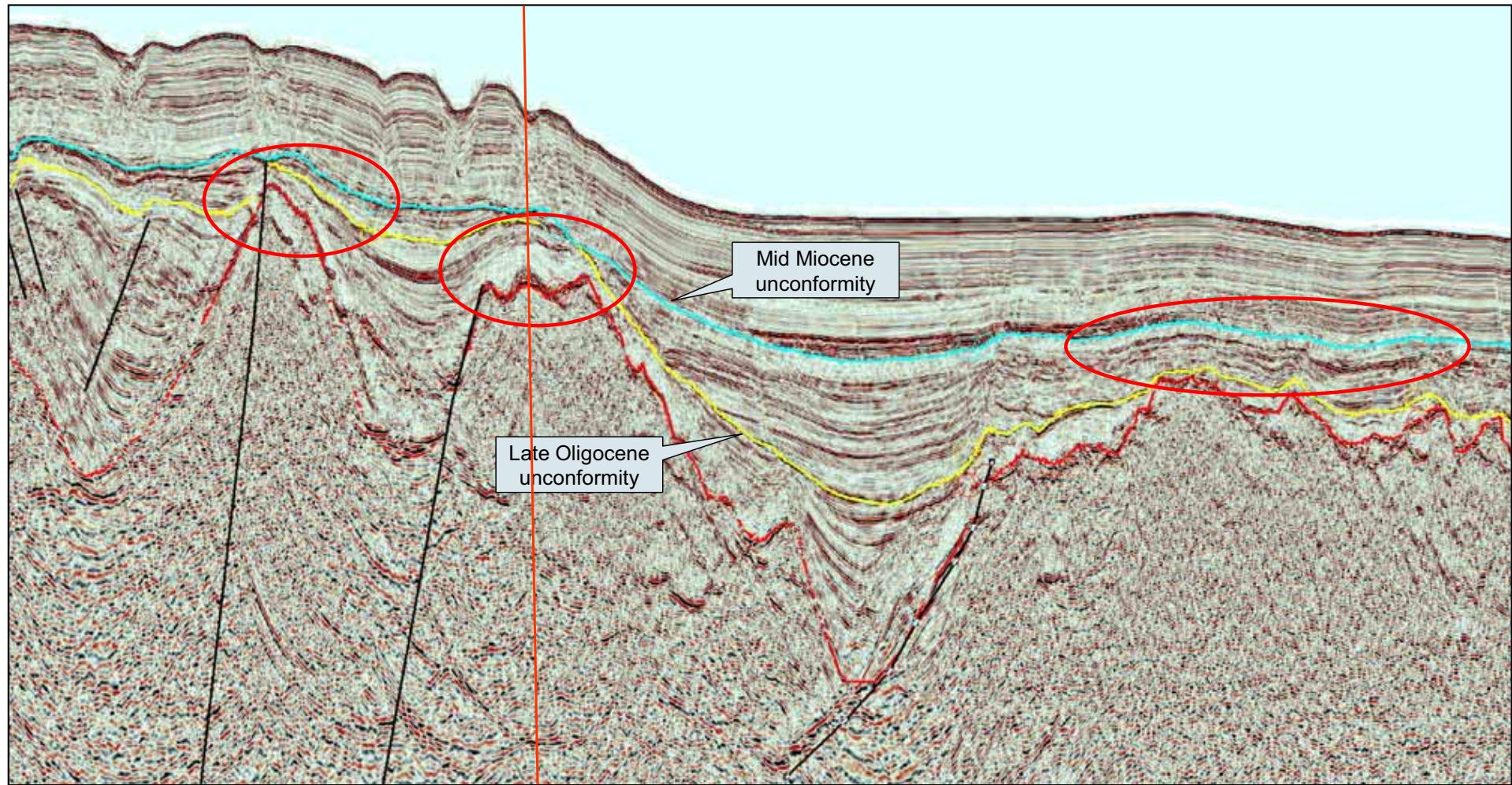


Upper Miocene Basin Floor Fan Lead



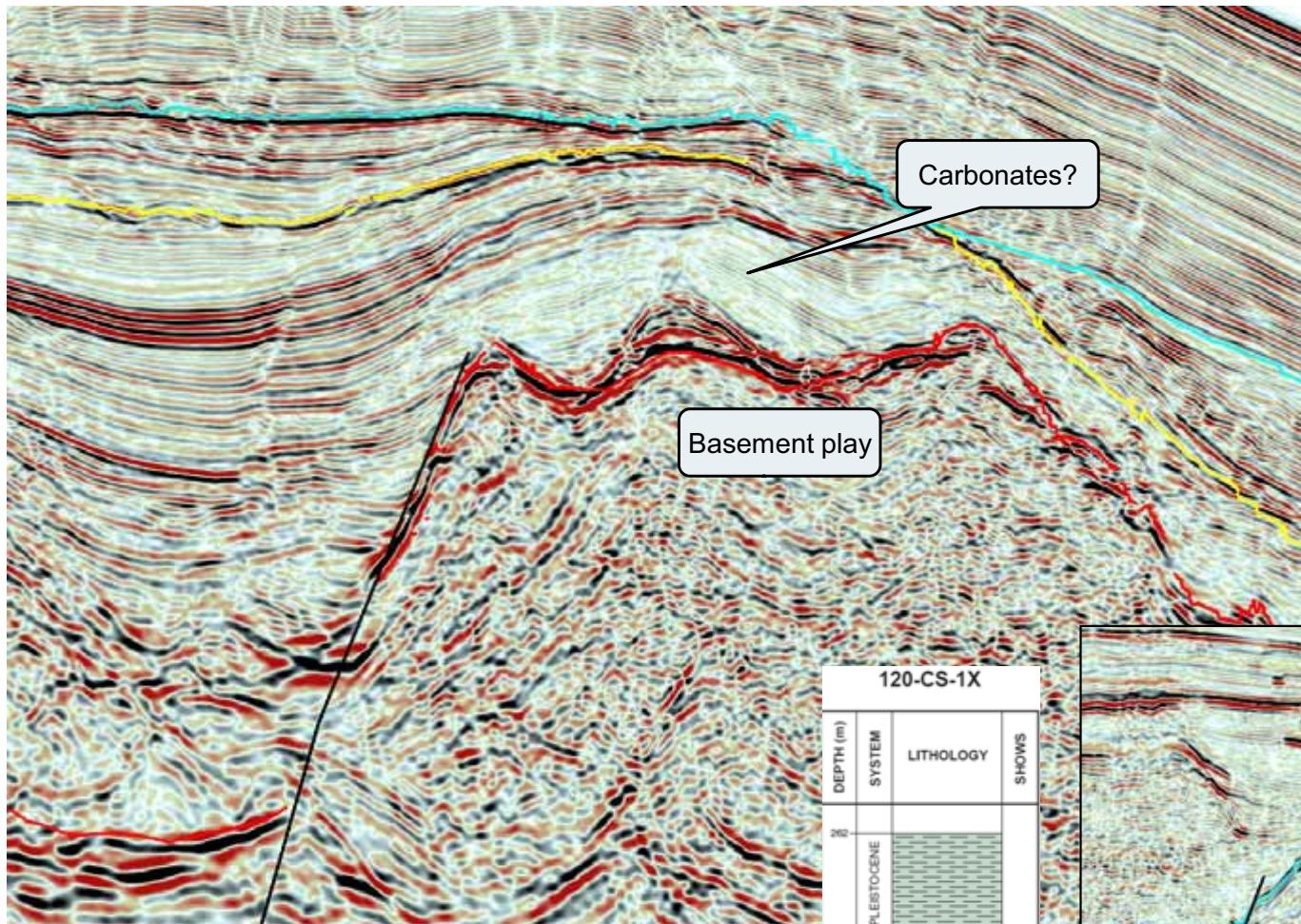
Example of leads along NW flank of PK Basin

NW Structural play with potential stacked reservoirs within basin floor and slope fans, shallow marine sands, SE basement and carbonates



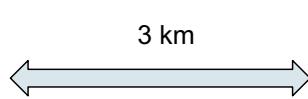
5 km



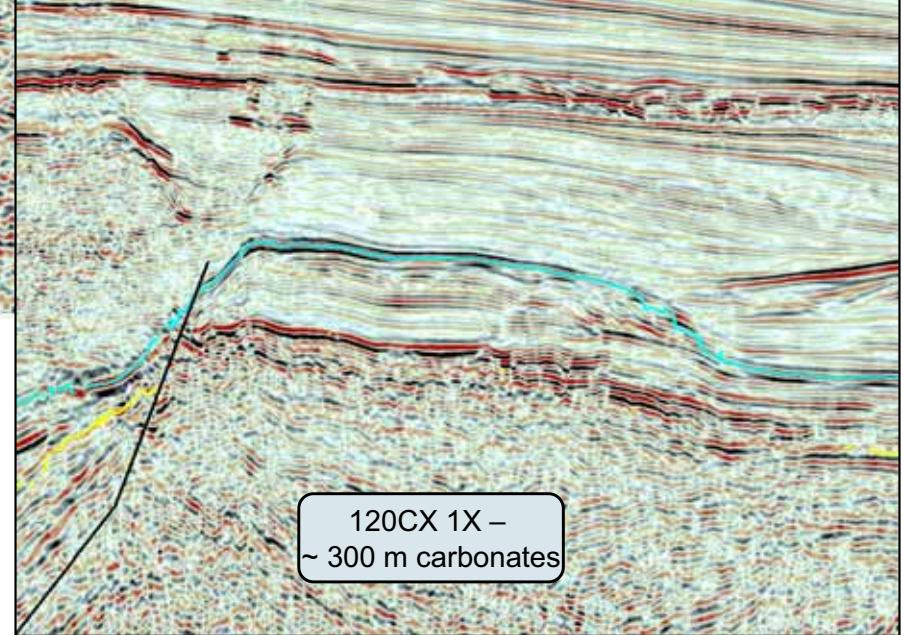


120-CS-1X		DEPTH (m)	SYSTEM	LITHOLOGY	SHOWS
E. MIO.	M. MIO.				
260					
785	LATE MIOCENE	PLIO - PLEISTOCENE			
1136					
1473	E. MIO.	M. MIO.			
1521					

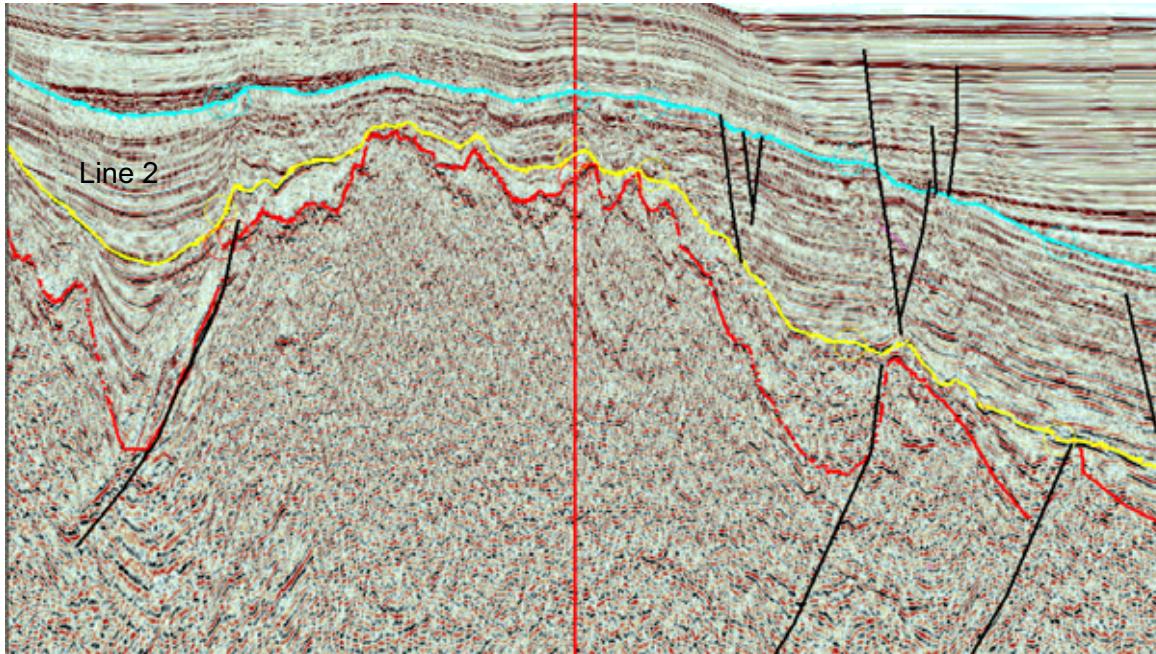
3 km



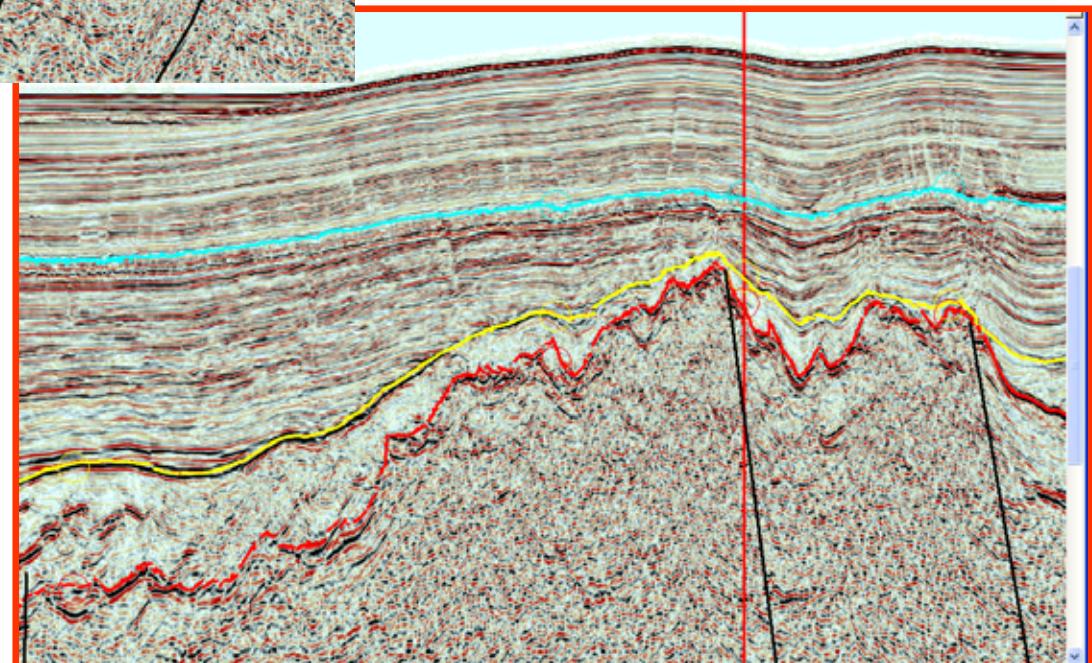
120CX 1X –
~ 300 m carbonates



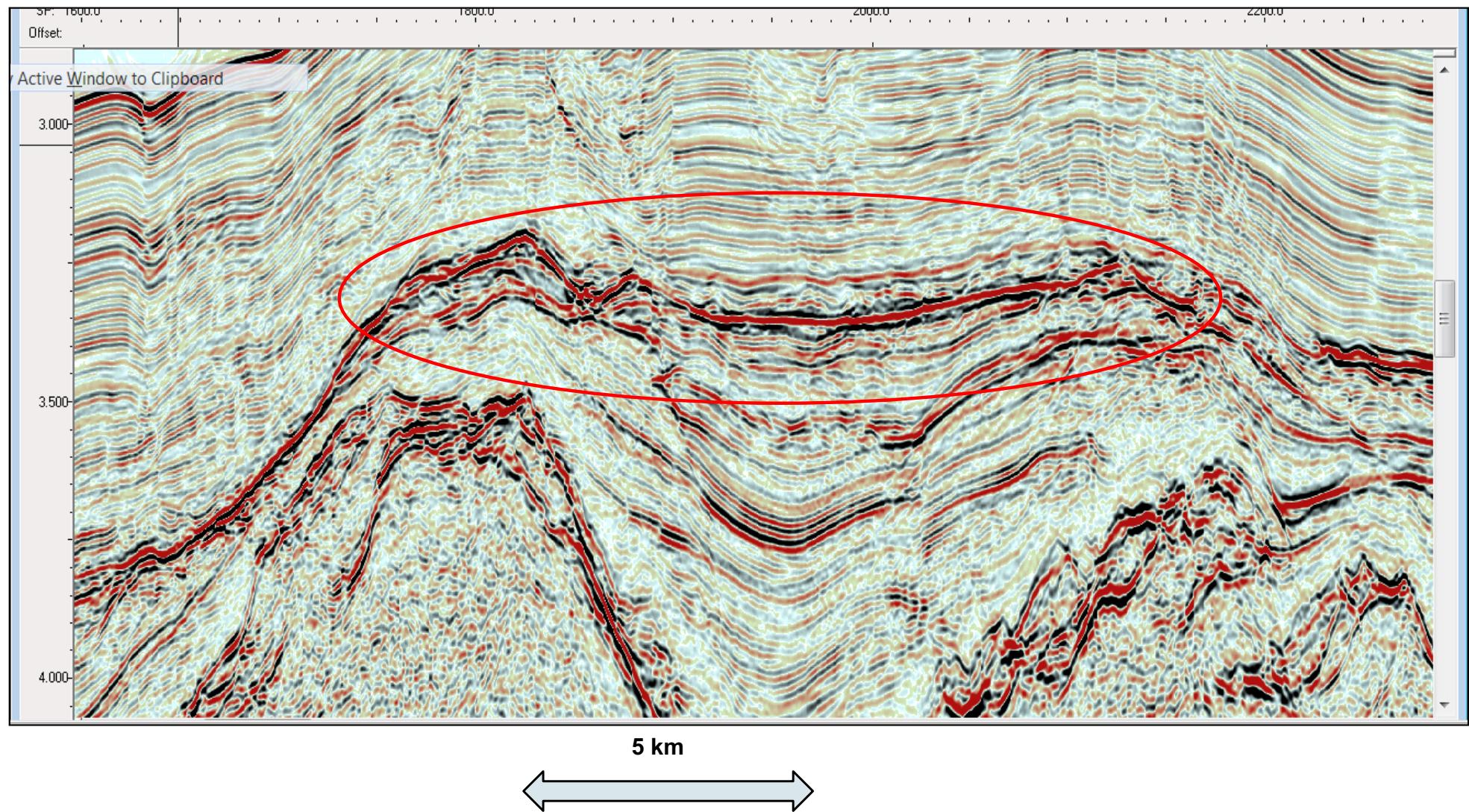
Example of leads along NW flank of PK Basin



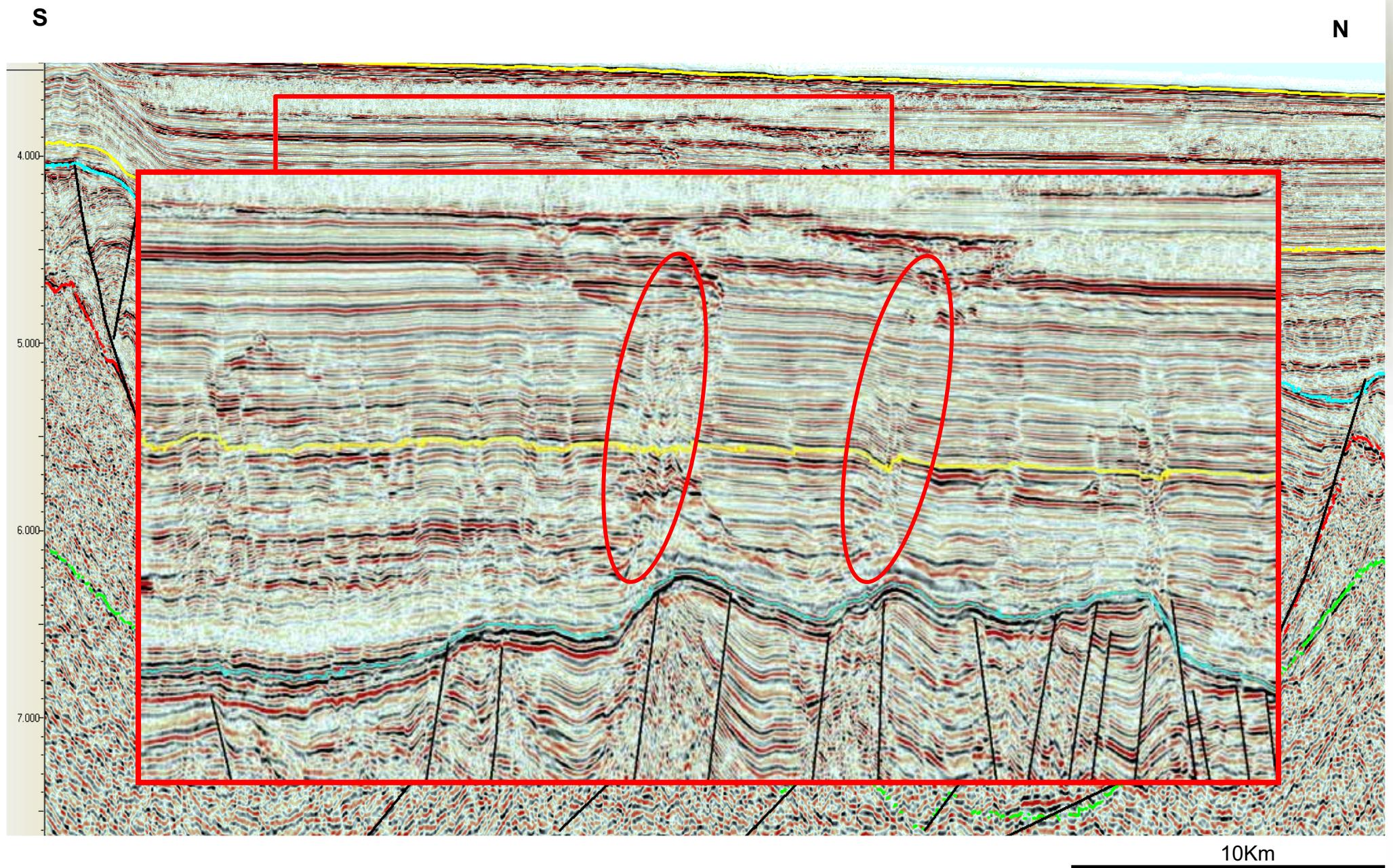
Structural play with potential stacked reservoirs within basin floor fans, shallow marine sands, basement and carbonates



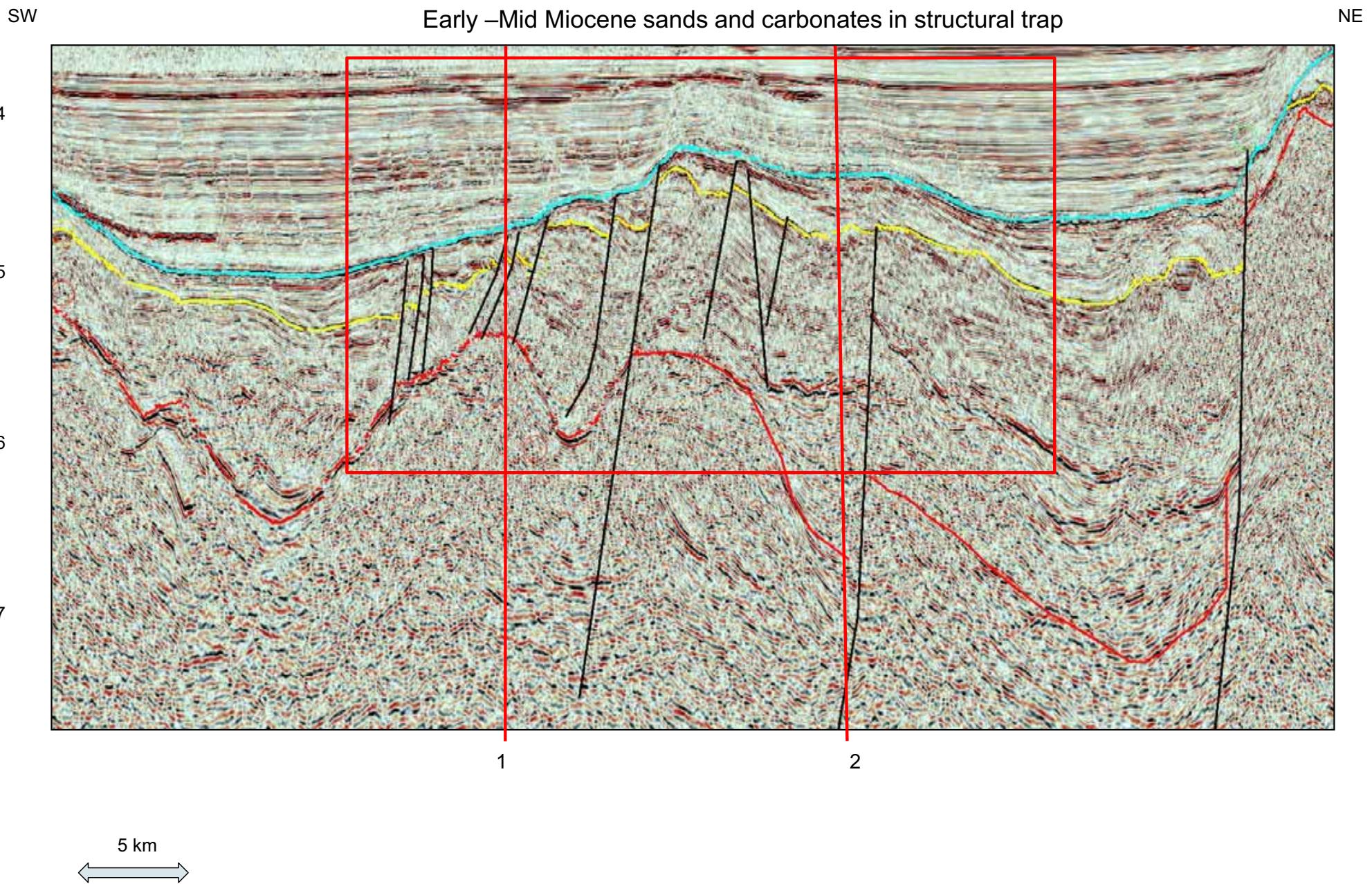
Example of leads along NW flank of PK Basin – example of carbonates build-ups



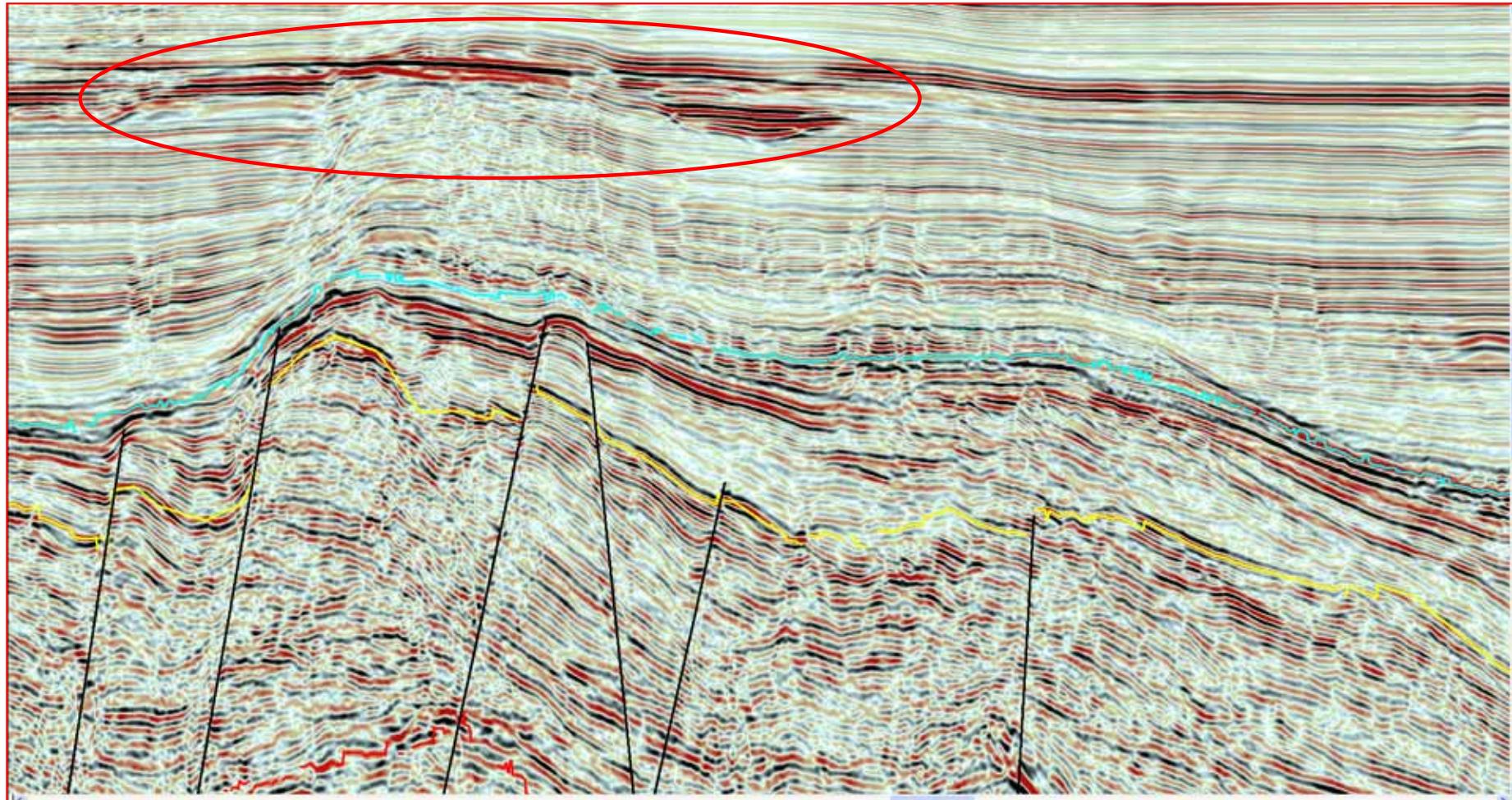
Southern part of PK area, rotated Lower/Middle Miocene fault blocks play



Example of leads in southern part of PK Basin



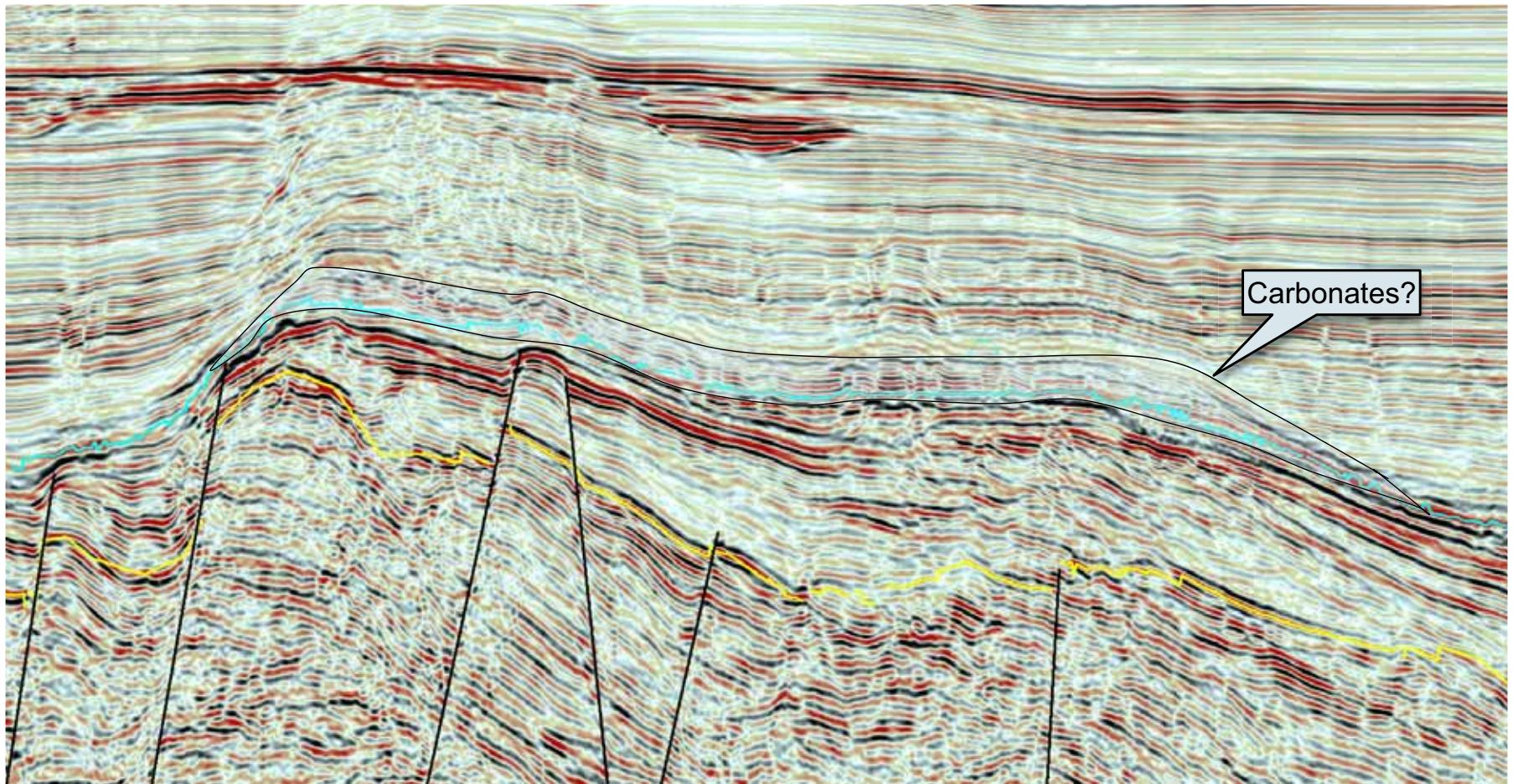
Example of leads in southern part of PK Basin



5 km



Example of leads in southern part of PK Basin



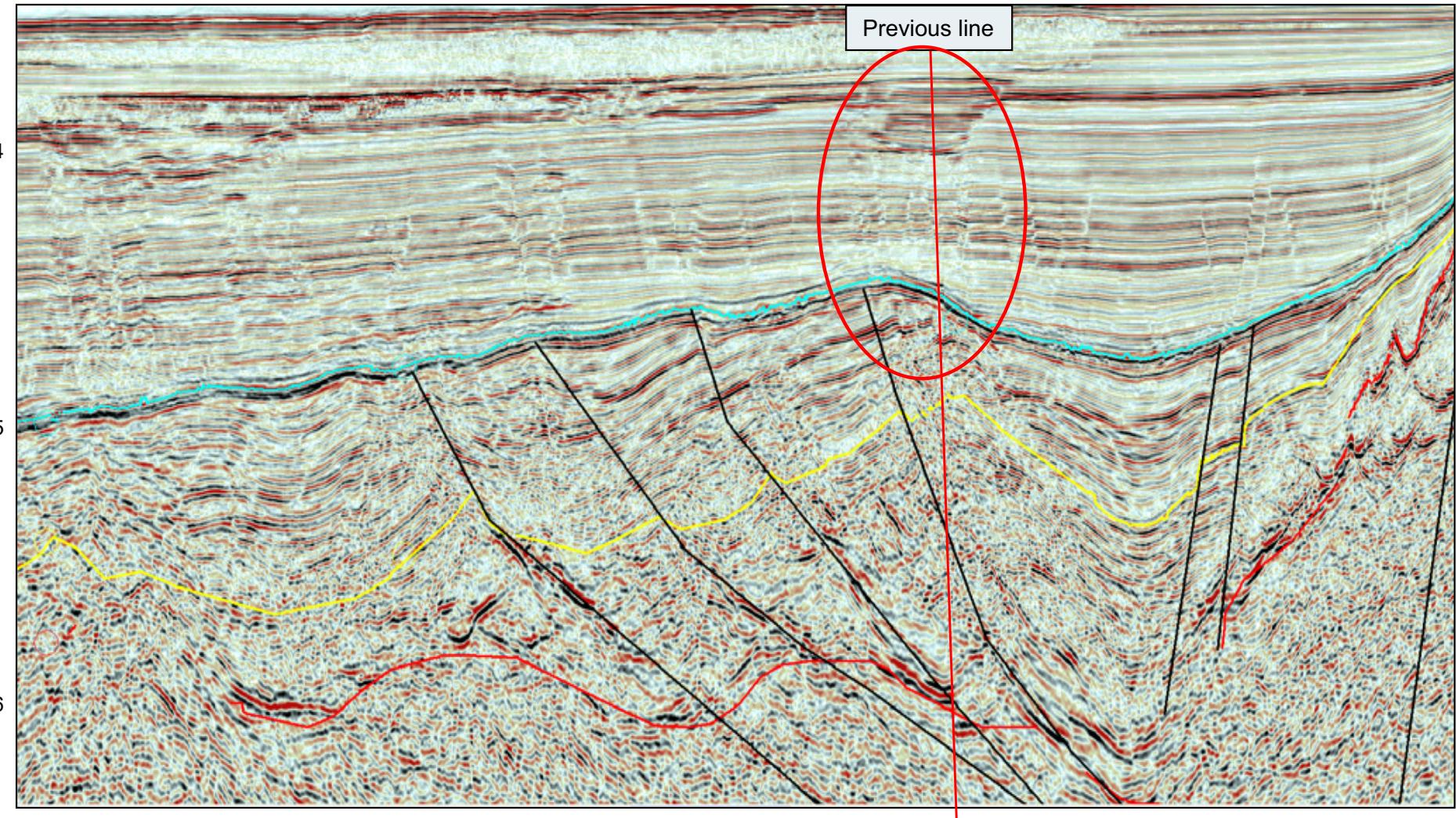
5 km



Example of leads in southern part of PK Basin

Line 1

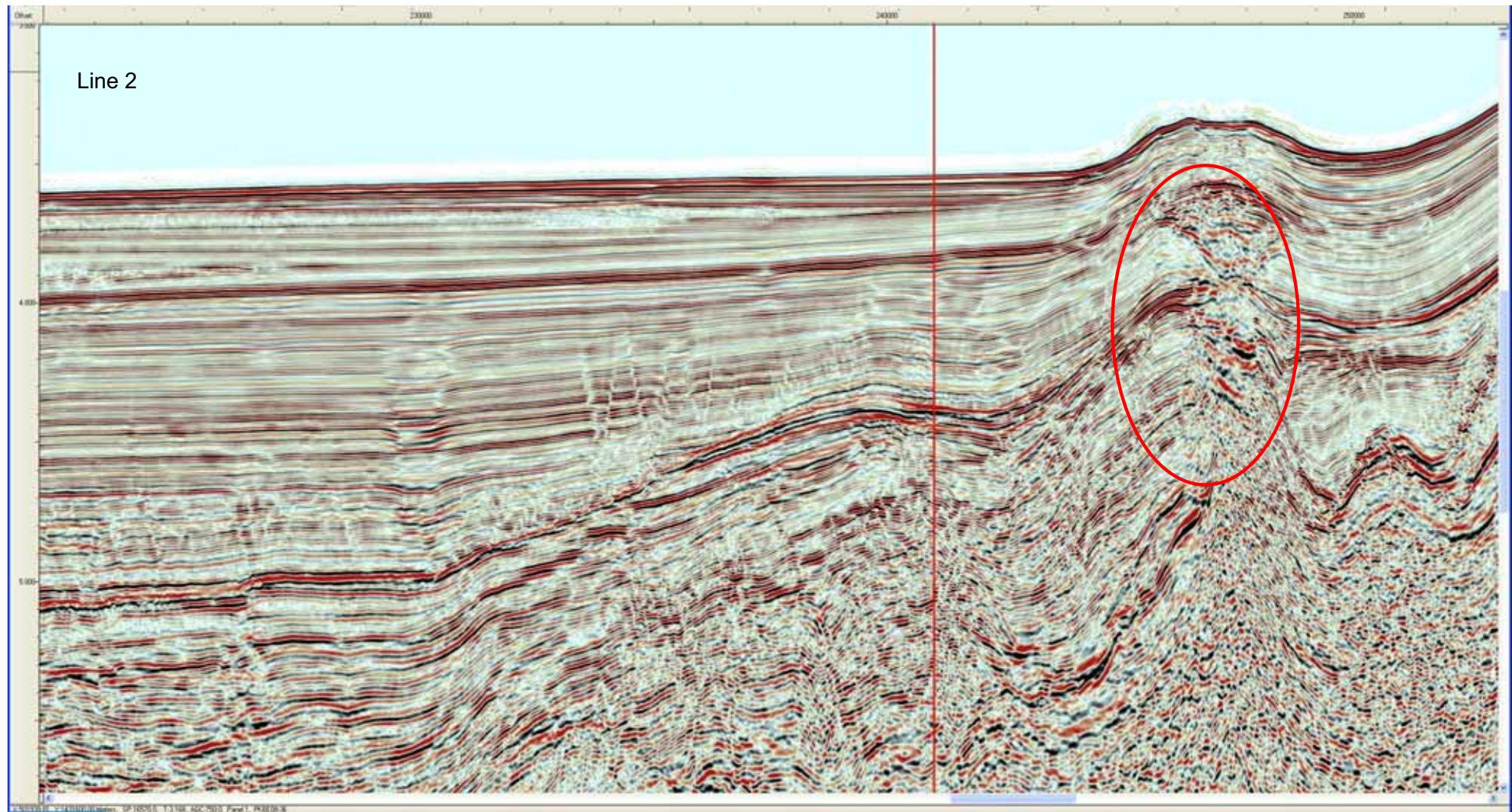
Early –Mid Miocene sands and carbonates in structural trap



5 km

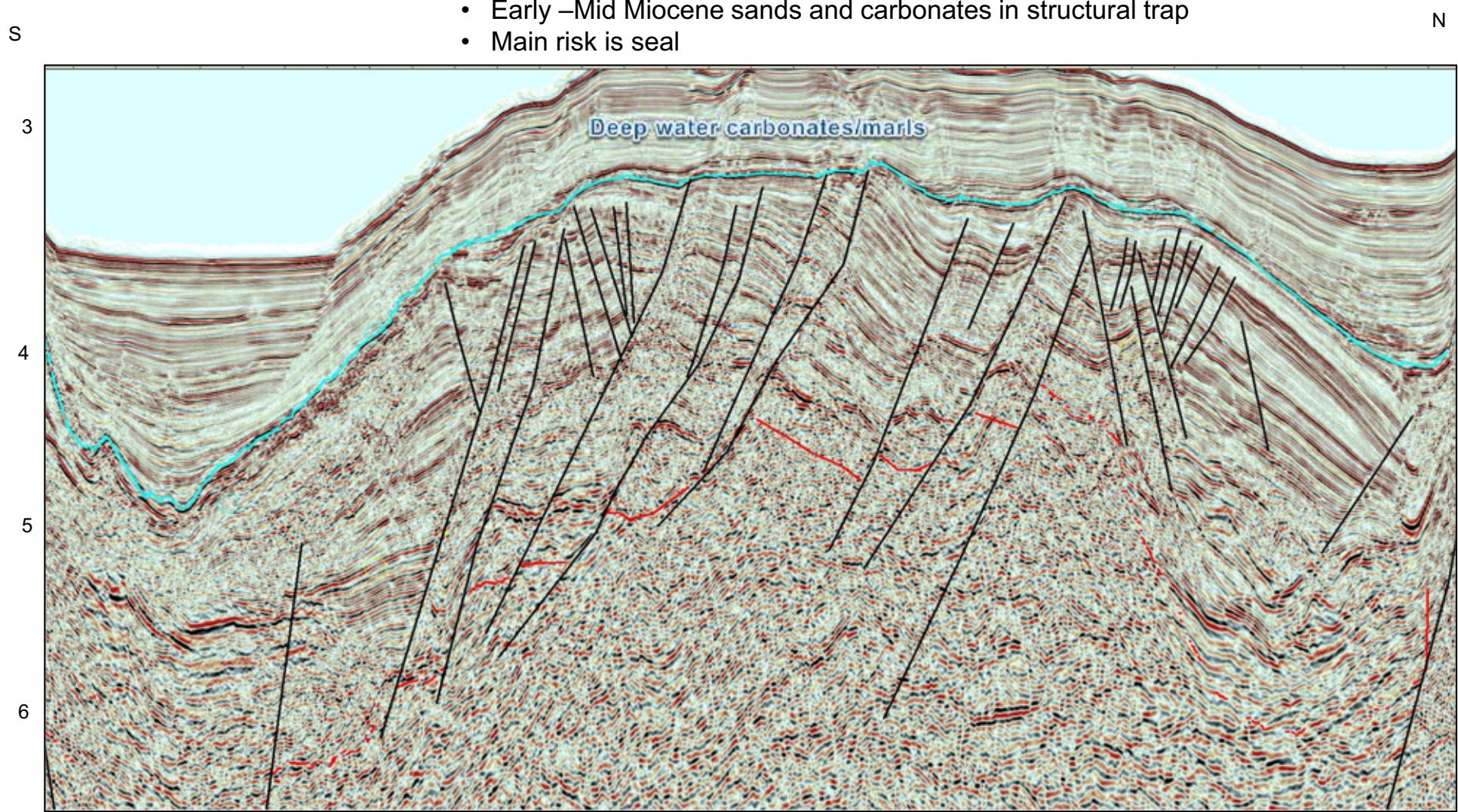


Example of leads in southern part of PK Basin



Example of leads in the PK “Uplifted areas”

- Early –Mid Miocene sands and carbonates in structural trap
 - Main risk is seal

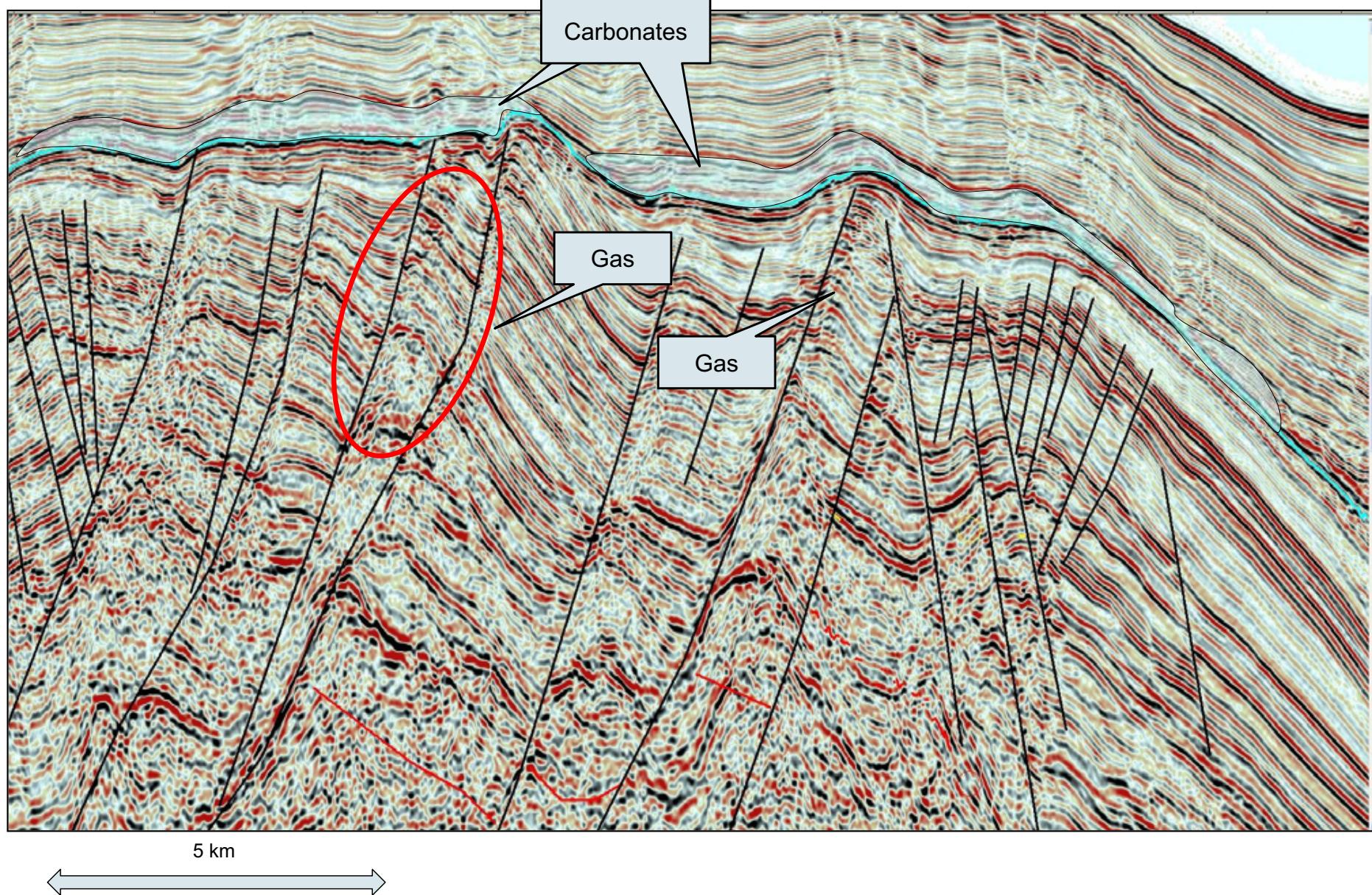


The lead has a 3-400 sq km closure

5 km

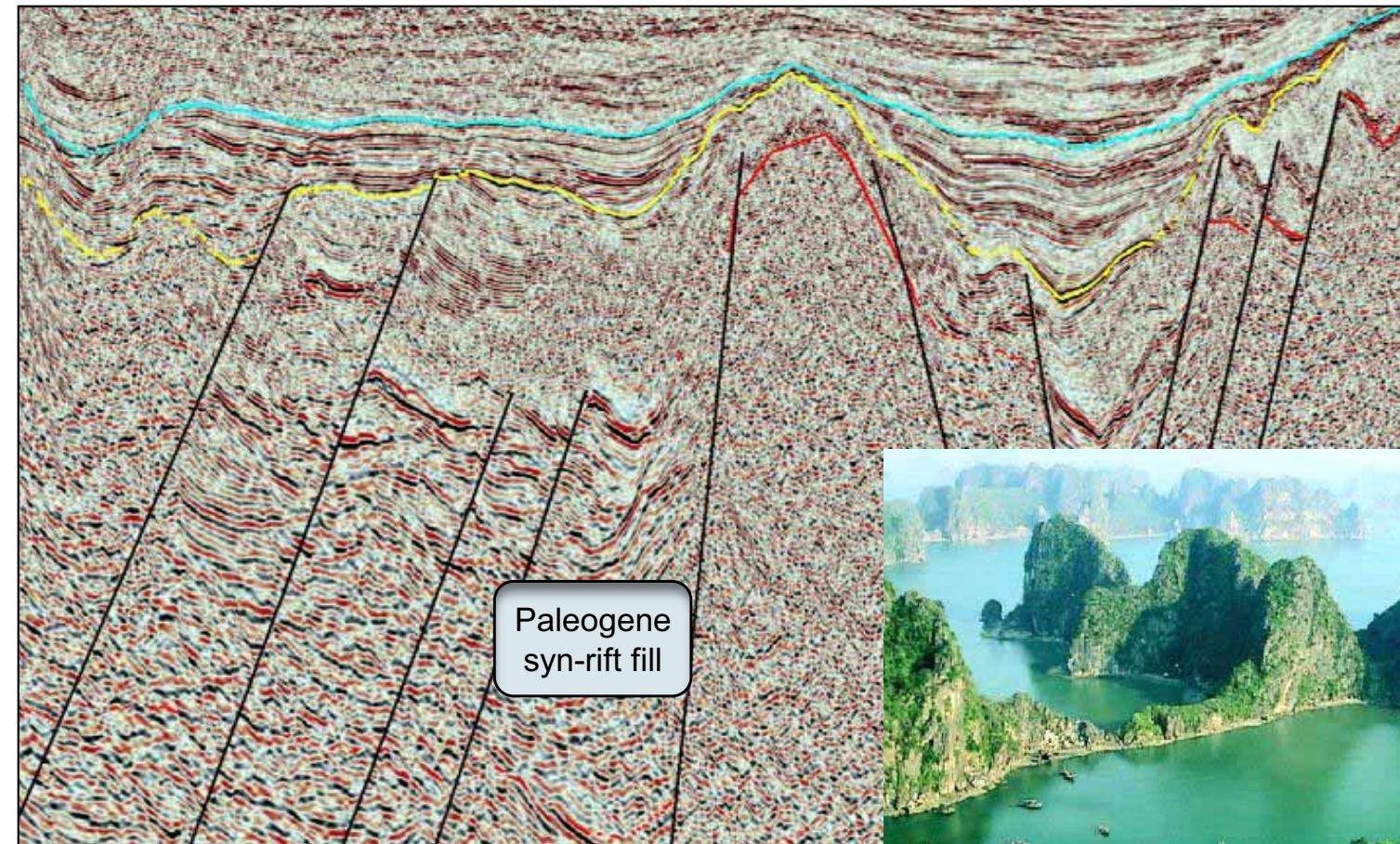


Example of leads in the PK “Uplifted areas”

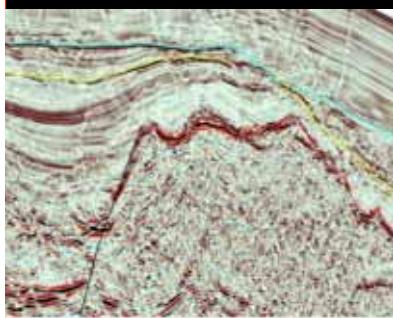
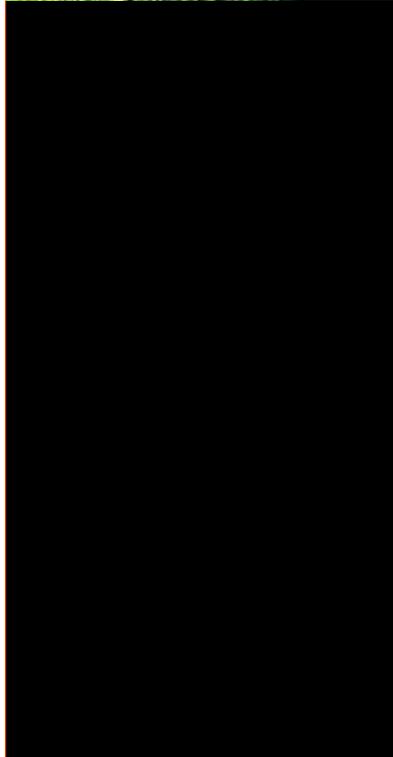


Example of leads along NW flank of PK Basin

Basement or pre-Tertiary carbonate play



Summary



- ✓ Phu Khanh Basin is one of the last frontier areas along the margins of SCS area, which structurally represent a very complex area
- ✓ Large part of the study area has well developed Paleogene rift basins related to lateral wrench movements along the East Vietnam Fault Zone, which are up to 2 -3 + km thick.
- ✓ The Miocene-Pliocene depocenter in central and southern party of area has up to 8-9 km of sediments where potential Early Miocene-Paleogene source will be thermal mature.
- ✓ The deepest part of the Paleogene syn-rift fill will be thermal mature in the northern part of the Phu Khanh Basin, which has up-to 4-6 km of sediments in the depocenters.
- ✓ The data has revealed a large number of structural and stratigraphic leads,.....
- ✓ and yes the area has the potential for large structures.
- ✓ Reservoirs comprise; shallow marine/fluvial sands, carbonates, fractured basement and basin floor fan sands. Main risk is;
 - Quality of Early-Mid Miocene clastic and carbonate reservoirs
 - Seal over parts of the area
 - Presence a valid source system (less risky!)
 - CO₂

Acknowledgements

PETROVIETNAM

