

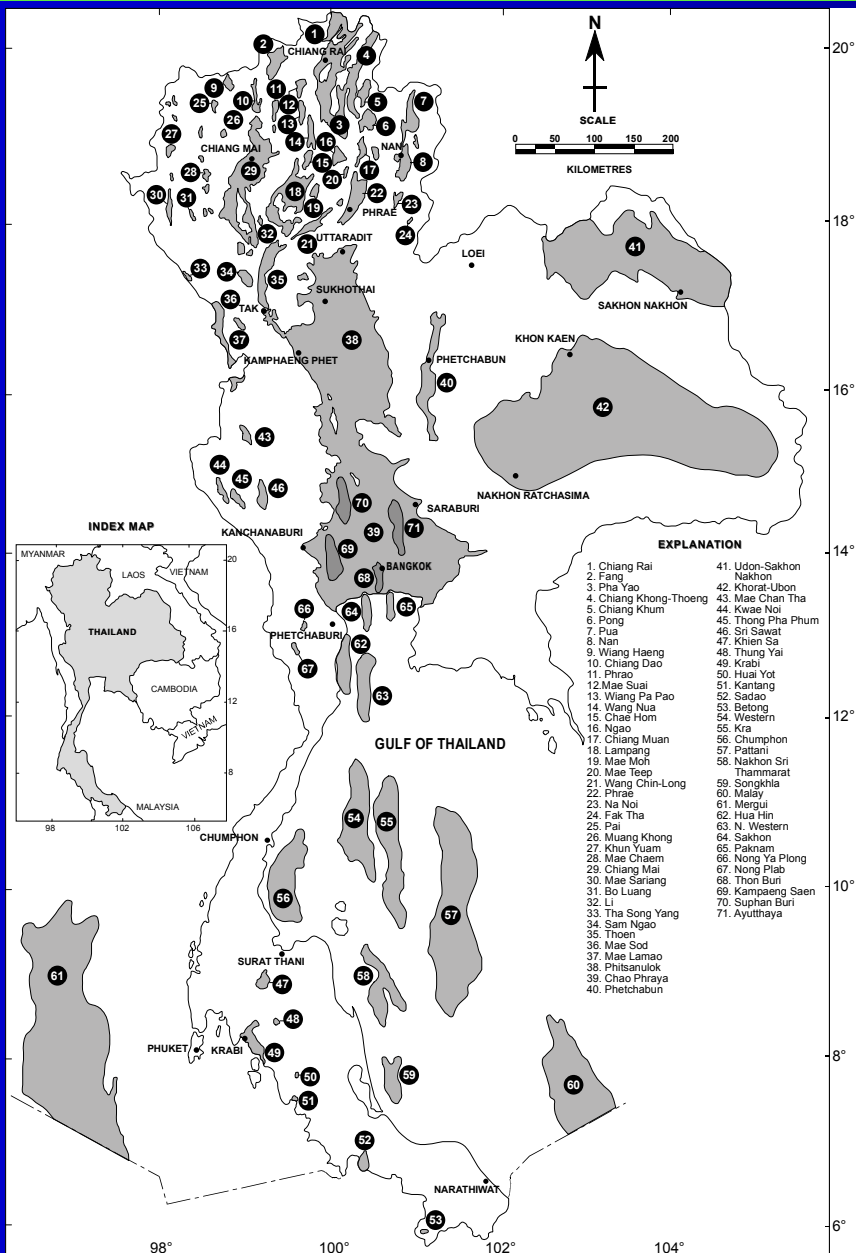
# Petroleum Potential in the rest northern Thailand basins

By

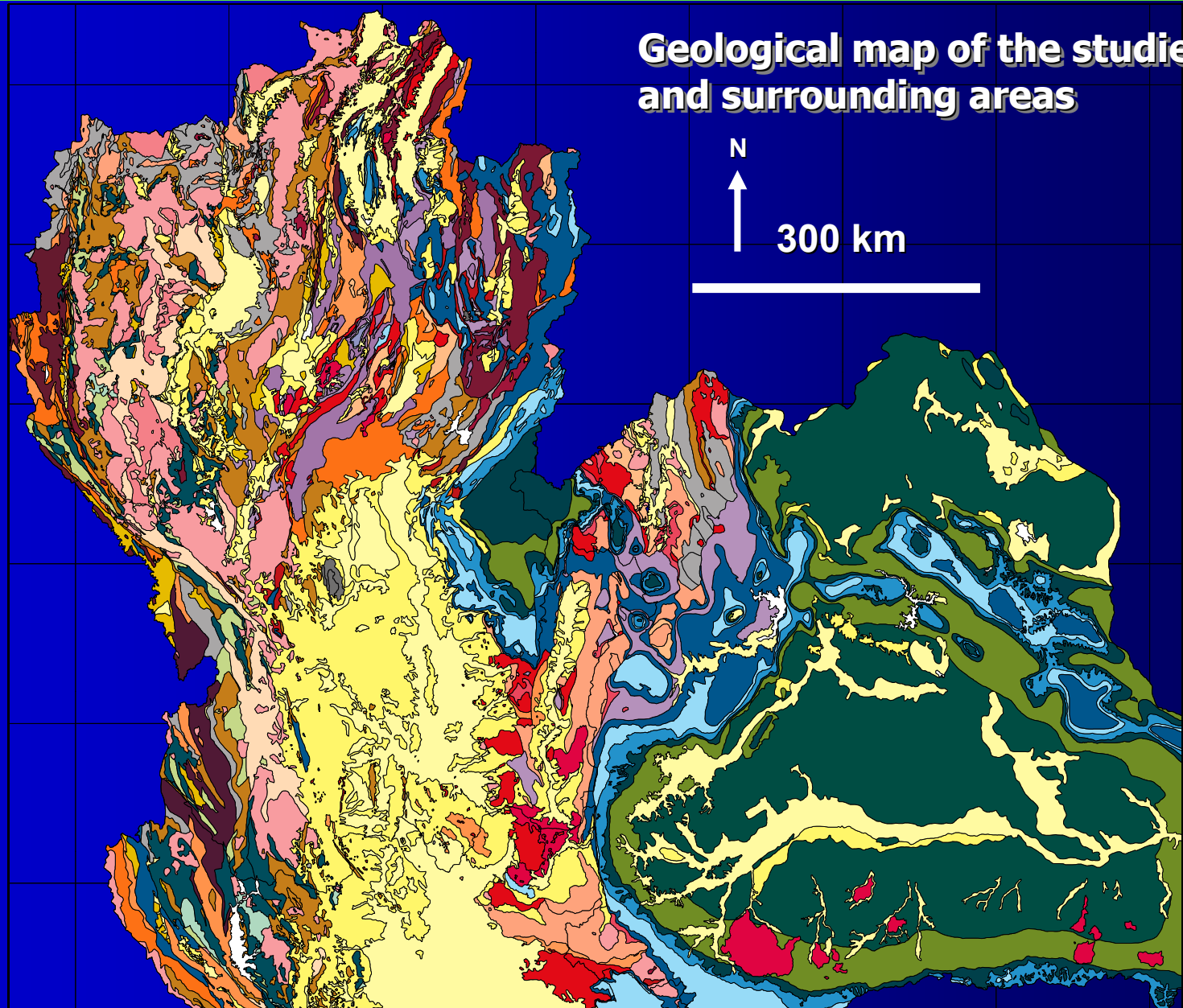
Phumee Srisuwon

## General Geology

- ✓ Regional geology and tectonics framework
- ✓ Basin models applied to the northern Thailand region
- ✓ Petroleum Geology
- ✓ Some examples of Tertiary sequence found in northern Thailand basins
- ✓ Burial history related to petroleum potential
- ✓ Conclusion



Map showing the distribution of the Cenozoic basins of Thailand (modified after Chaodumrong *et al.* 1983, Chinbunchorn *et al.* 1989 and Uttamo 2000)





## TECTONIC MAP OF CENTRAL-EAST ASIA



Tectonic map of central-east Asia illustrating 'Extrusion' model and its relationship with Cenozoic structures in the region. Numbers in white arrows indicate the relative order in which certain continental blocks were extruded toward the southeast. After Tapponnier *et al.* (1982).

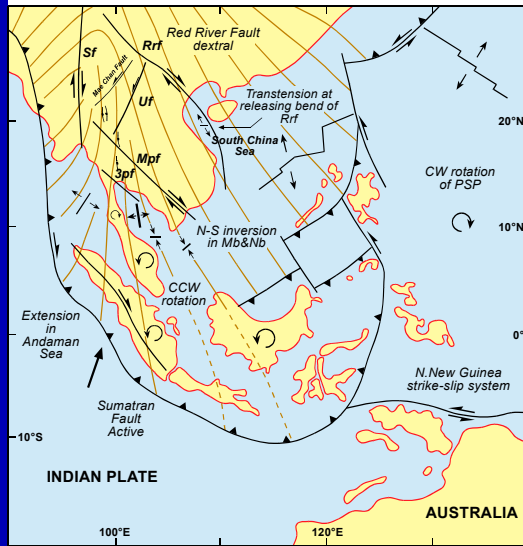
# The 1<sup>st</sup> DMF Technical Forum 18<sup>th</sup> May 2007

**Present Day Tectonics of the Sunda Shelf**



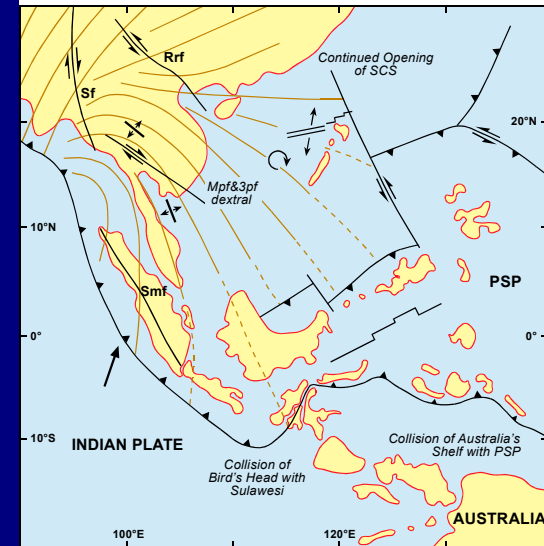
**TECTONIC RECONSTRUCTION OF THE SUNDA SHELF**

**15 Ma: Middle Miocene**



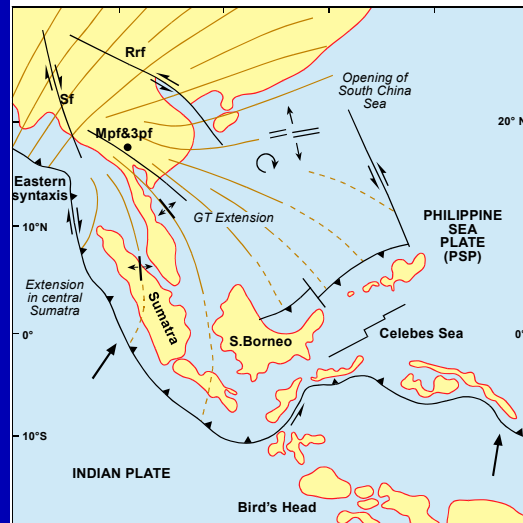
**TECTONIC RECONSTRUCTION OF THE SUNDA SHELF**

**23 Ma: Early Miocene**



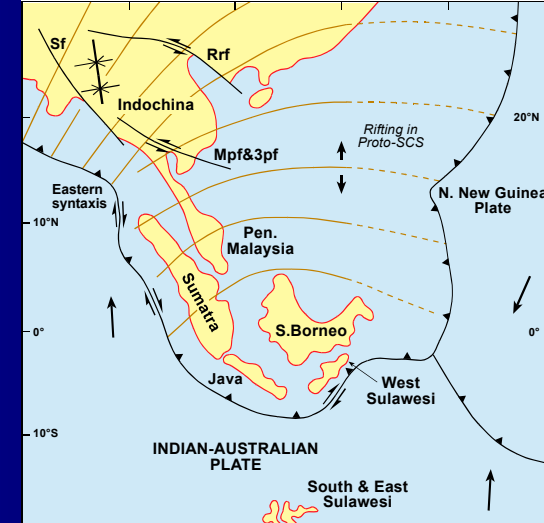
**TECTONIC RECONSTRUCTION OF THE SUNDA SHELF**

**32 Ma: Early Oligocene**



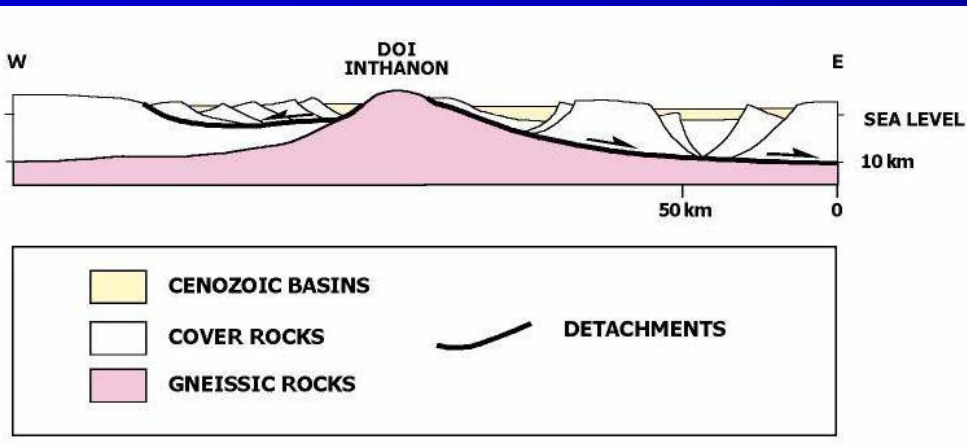
**TECTONIC RECONSTRUCTION OF THE SUNDA SHELF**

**50 Ma: Middle Eocene**



Maps showing position of major plates in SE ASEA during Tertiary period.

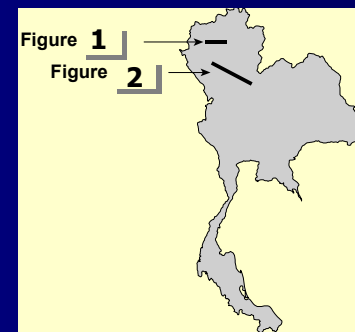
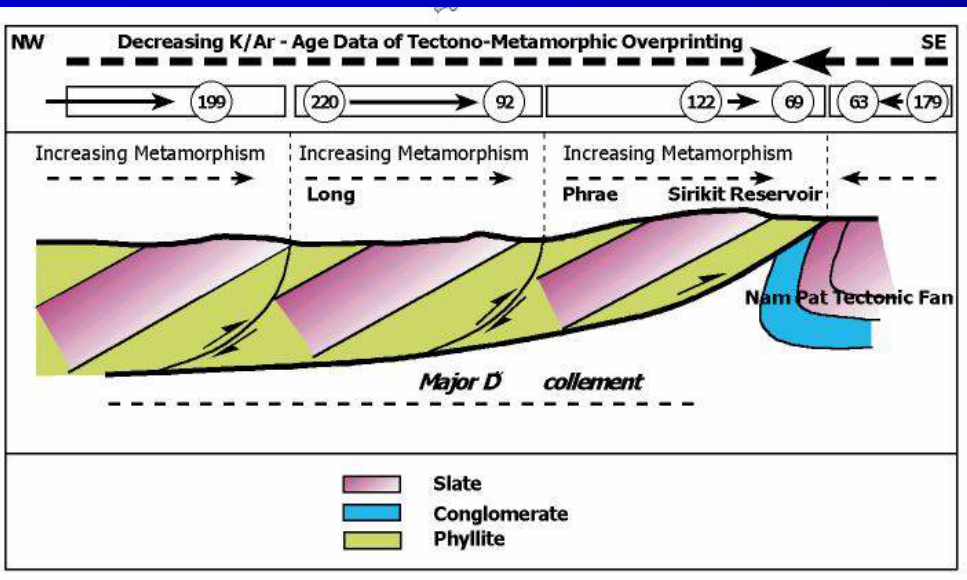
Modified after Huchon *et al.* (1994), Hall (1996), Longley (1997) and Chantraprasert (2000)

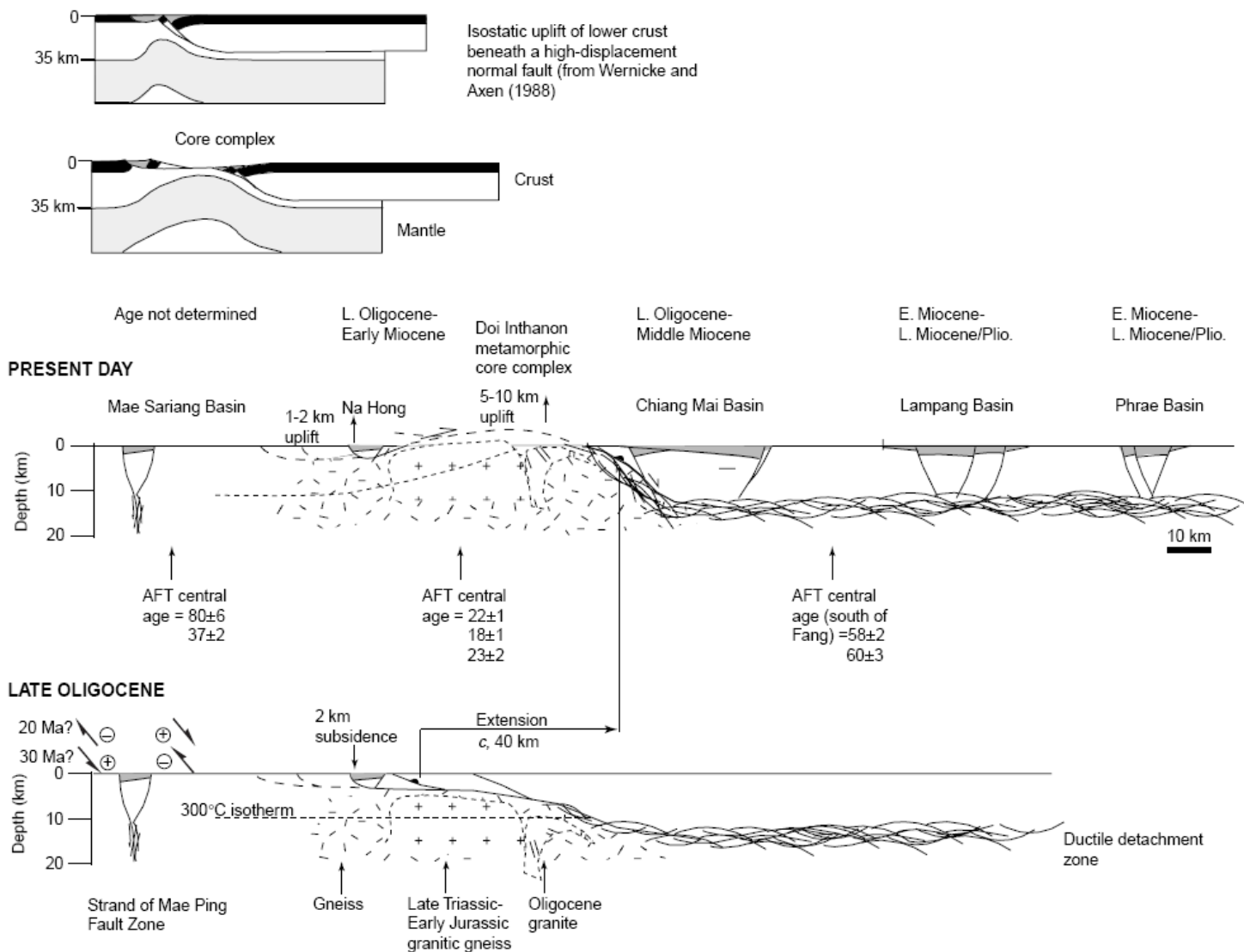


## Basin Models

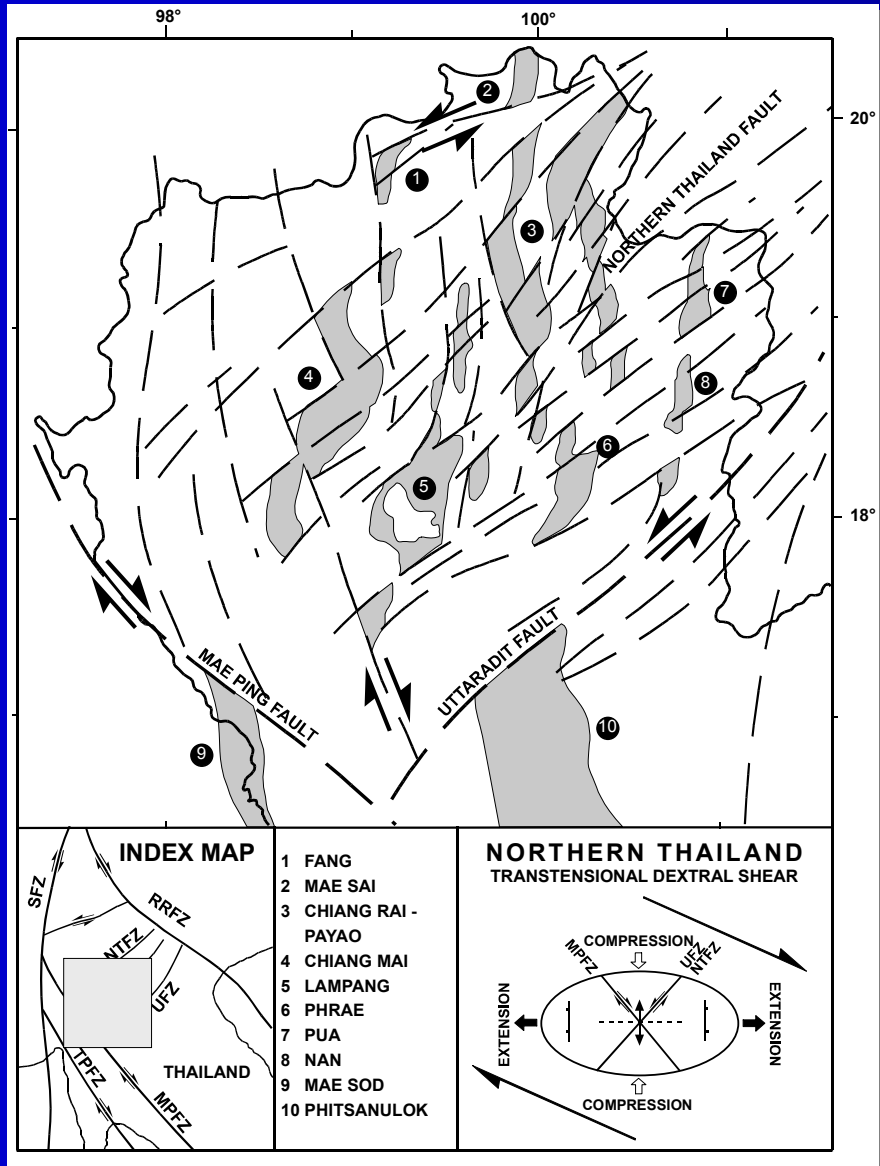
1. Gravitational collapse  
 Structural model illustrating linkage between the core complex and basin development in northern Thailand (after Dunning *et al.* 1995).

2. Thrust tectonic  
 Thrust or Nappe tectonic model for the development of the Tertiary basins in northern Thailand by distribution of the K-Ar age data in across section Lampang-Sirikit Reservoir. (after Ahrendt *et al.* 1993).

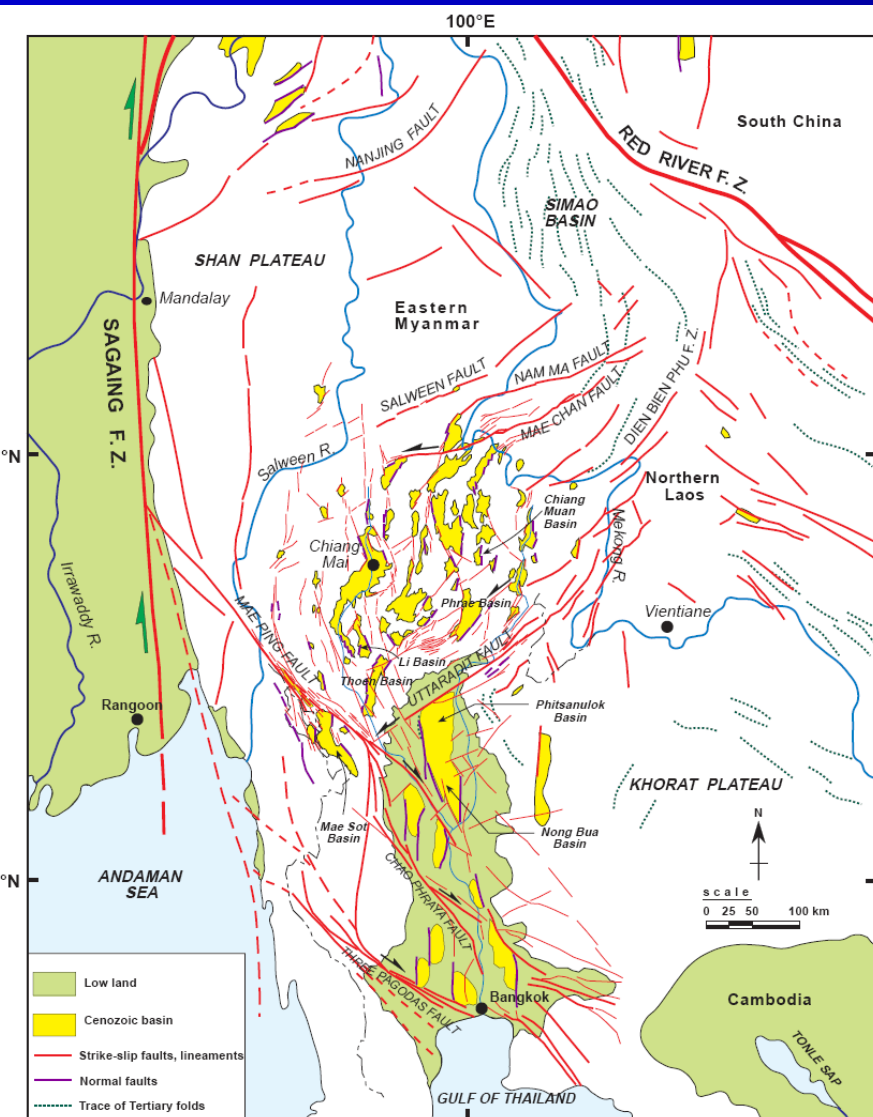




**Figure 6.20** Geological cross section across northern Thailand rift basins related to the development of the core complex during Late Oligocene and Present day. Reconstruction from apatite fission track and mica cooling ages (after Morley *et al.* 2001)



3. Basin associated with strike-slip faults  
**Sketch structural map of Northern Thailand showing relationship between conjugate strike-slip faults and the development of N-S trending pull-apart basins (Polachan *et al.* 1991)**



**4. Northern Thailand fault-wedge moves out**  
**The sinistral Mae Chan Fault acts as a northern boundary while the dextral Mae Ping Fault is a southern boundary of the northern Thailand wedge. The main E-W extension occurred within the northern Thailand wedge as a product of N-S compression regime (Elders *et al.* 2000)**

Figure 6.21 Structural map of Mainland Southeast Asia showing the present day relationship between Cenozoic basins in northern and central Thailand with main strike-slip faults, normal faults and lineaments. Structural data of northern Thailand modified after Uttamo (2000), central Thailand from Tulyatid (1997), eastern Myanmar and southern

## Petroleum Geology (1)

- **Reservoirs and seals**

**All formations with good porosity sand can be a reservoir, generally found in Lower Pratu Tao (fluvial sand intercalated with ephemeral lake clay), Lan Krabu (fluvio-lacustrine) and some in Khom Formations. A potential for seals are associated within all formations but excepted in the younger coarse grained sediments of the Ping and Yom Formations.**

**The host block that is located next to the E to NE of the Sukhothai Depression could be next target where it is shallow up to NE area of the northern Phitsanulok Basin.**

**The W to NW of the Sukhothai Depression where the part of distal fans would play an important role for reservoir.**

**However, the eastern part of northern Phitsanulok Basin is still interesting for some of stratigraphic play.**

## Petroleum Geology (2)

- **Source rocks and maturation**

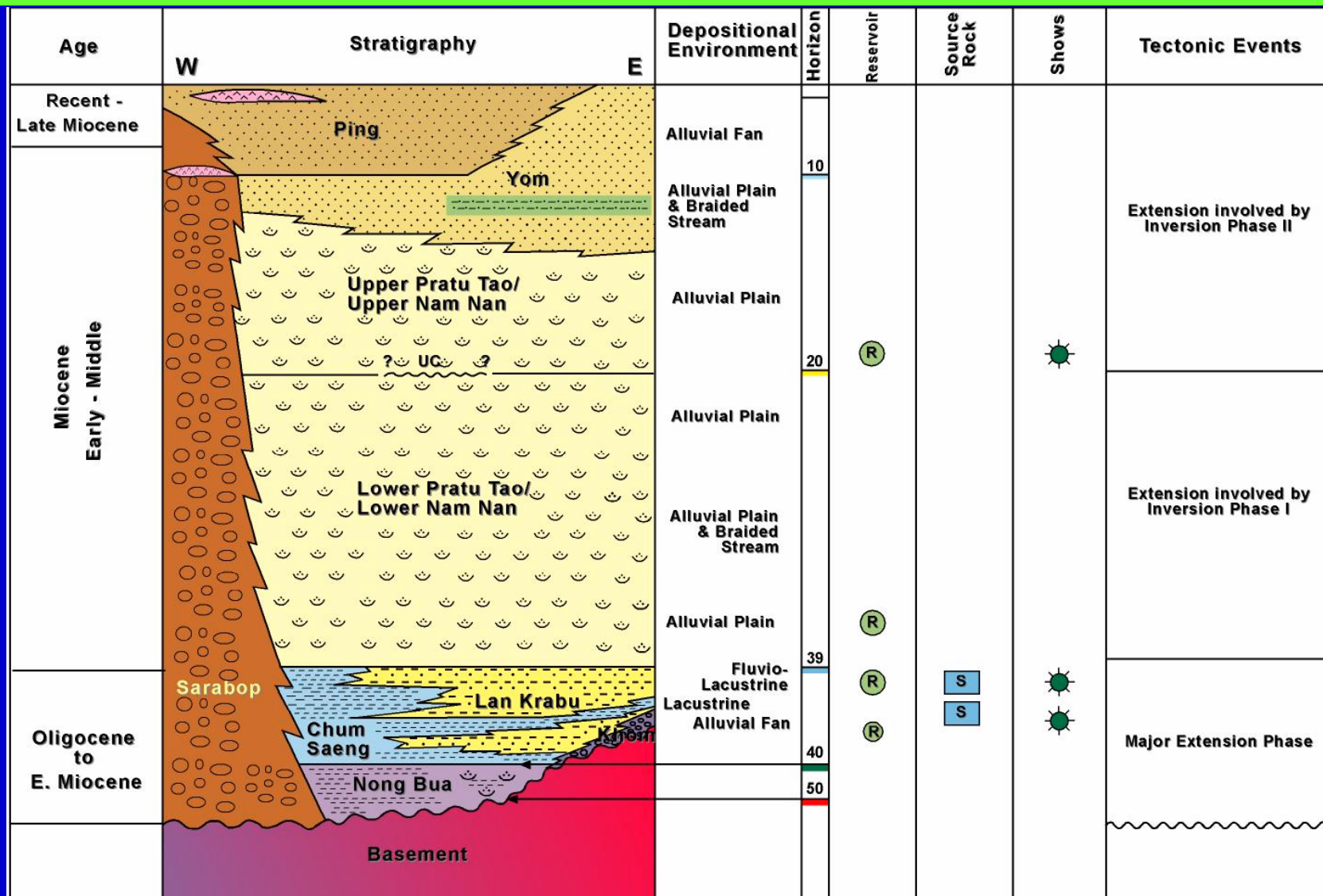
Major source rock is in Chum Saeng and Nong Bua Formations. Generation and expulsion took place at depth exceeding 4,000 m in Sukhothai Depression.

- **Migration and entrapment**

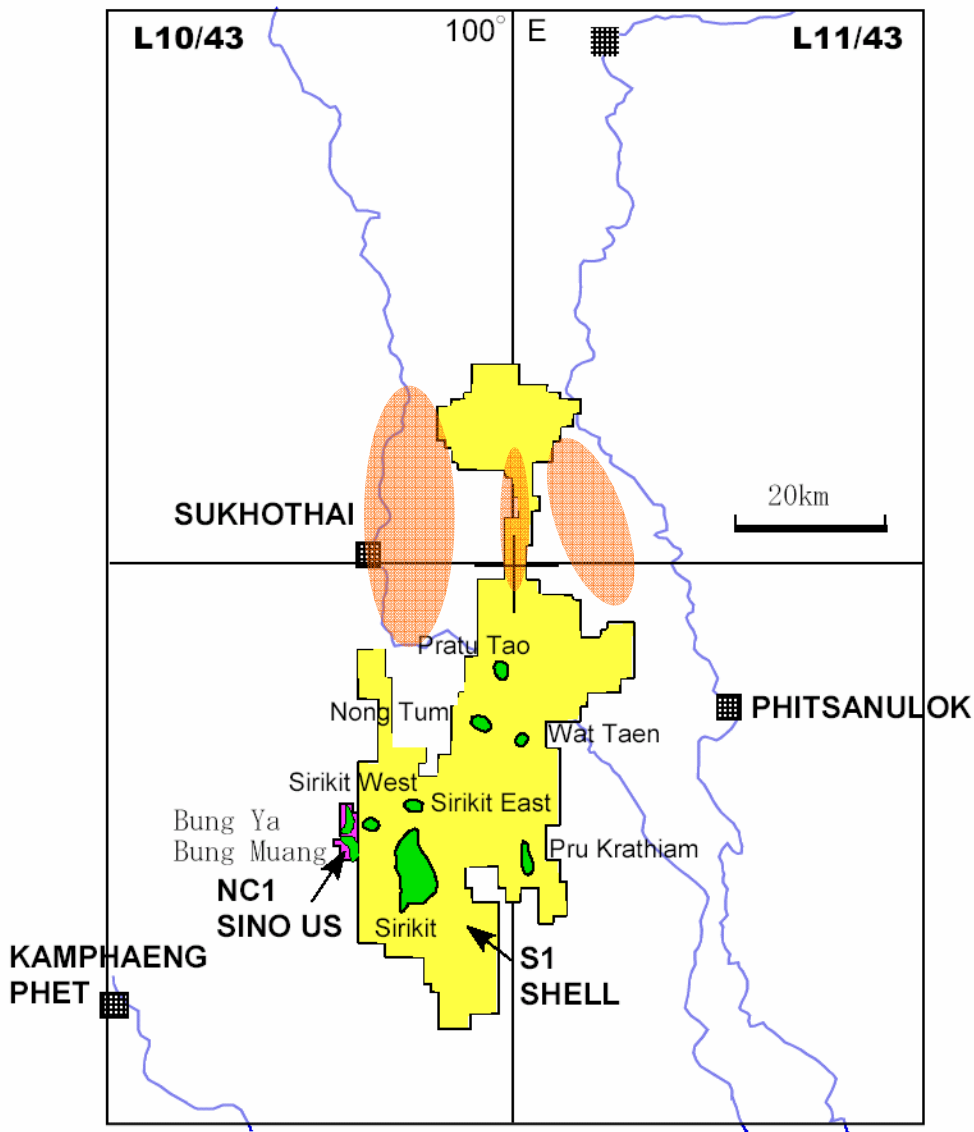
Hydrocarbons have been found up to 5 km from the main kitchen and filled within the structural fault traps (Pratu Tao-A1) whereas stratigraphic traps have been found at about 16 km NE to ENE of the kitchen (Mae Nam Nan area).

The above mentioned petroleum geology is some example from the northern Phitsanulok basin where most areas are already occupied by several oil companies. However, the source rock is not a problem with most Tertiary sedimentary basins because the middle part of syn-rift or rift fill sequence is dominated by lacustrine environment which is believed to be a good potential for petroleum and coal deposits.

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**Idealized stratigraphic section over former ThaiShell area (northern part of the Phitsanulok Basin)**



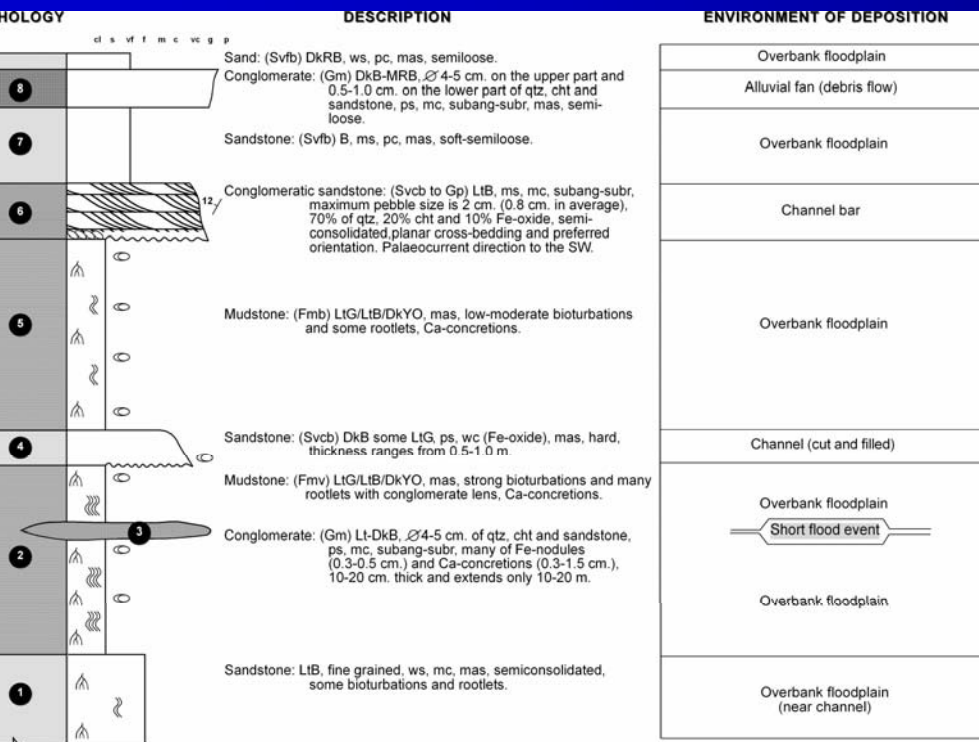
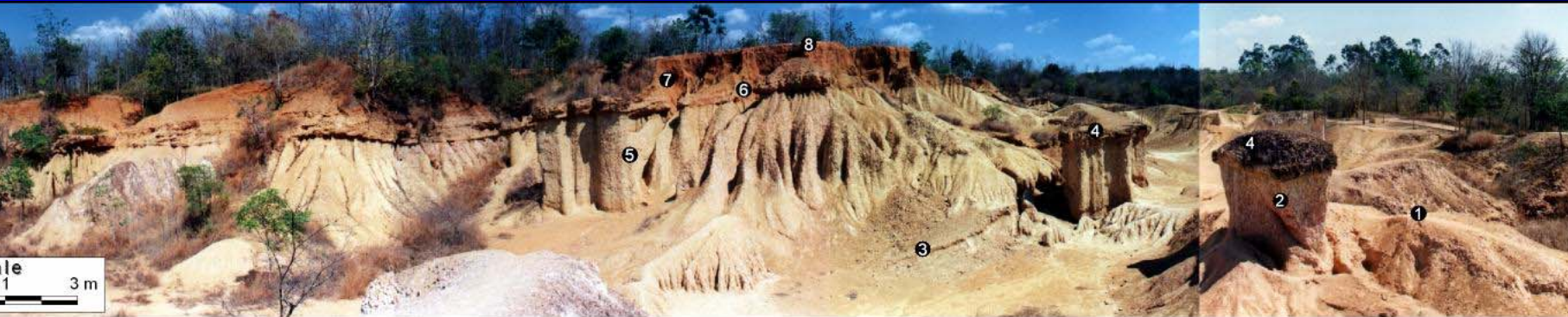
Concession Map



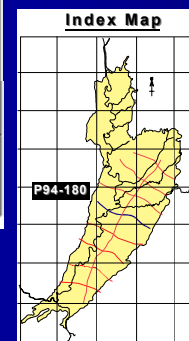
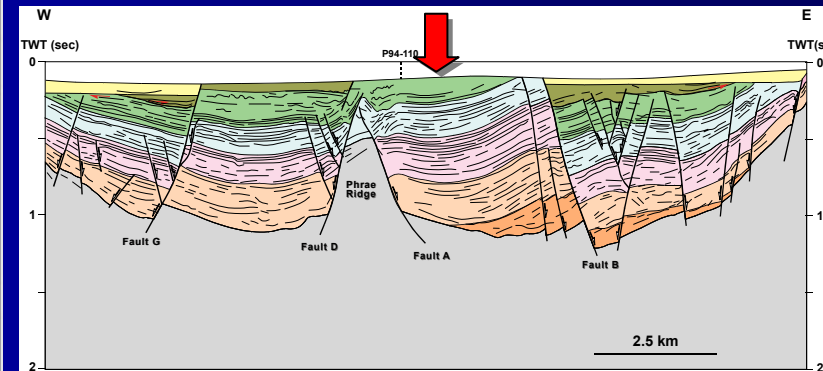
Example from Phrae Basin

**Typical grey shale source rock deposited in a shallow lacustrine environment, *Viviparus* Sp. and coal beds are very common (Srisuwon 2002).**

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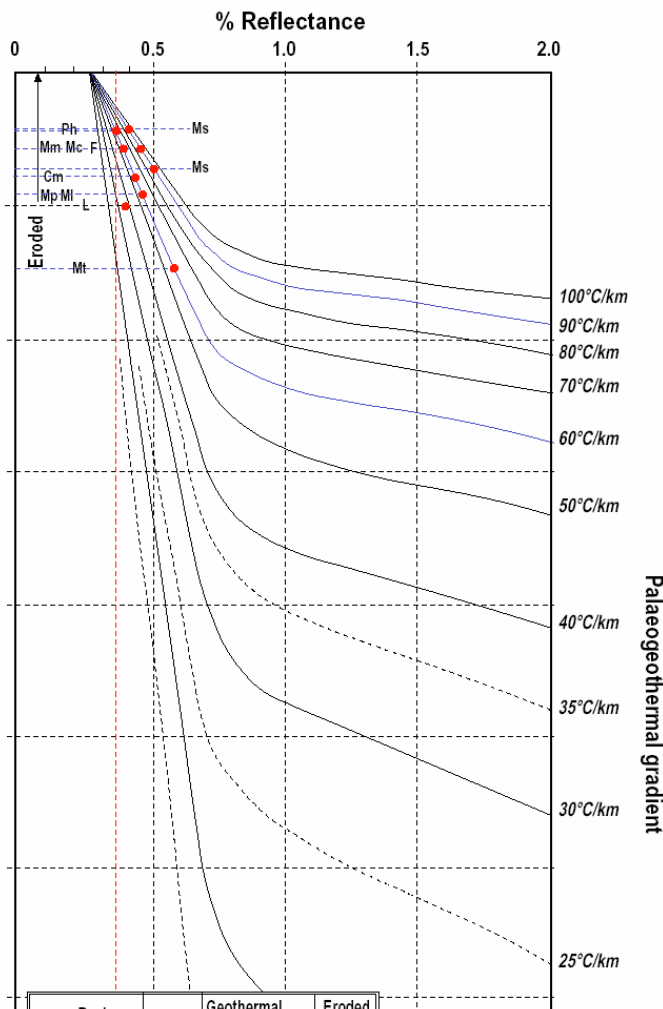


**Typical channel and floodplain deposits on the upper and lower parts of Tertiary sequence in northern Thailand basins (Srisuwon 2002).**



**Phrae Basin was targeted for coal exploration by DMR in 1996-1997 while seismic survey was done by PTTEP in 1994 aimed for petroleum.**

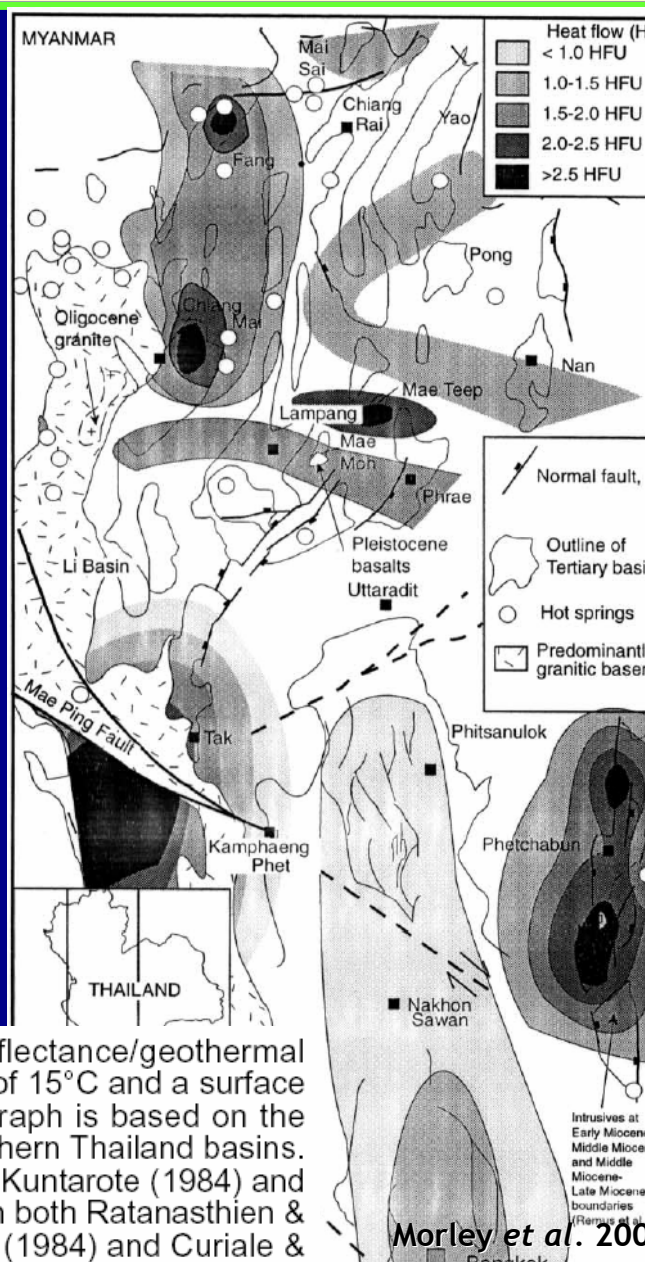
**Interpretation of the above section (Location: Phae Muang Phi National Park, Phrae Basin, ~100 km north of the Phitsanulok Basin)**



Basin	Ro(%)	Geothermal gradient (°C/km)	Eroded (m)
Phrae (Ph)	0.35	60	450
Mae Moh (Mm)	0.37	60	550
Li (L)	0.38	35	1000
Mae Teep (Mp)	0.46	60	920
Mae Tun (Mt)	0.58	60	1500
Mae Lamao (Ml)	0.45	60	900
Mae Chaem (Mc)	0.38	60	560
Fang (F)	0.44	90	550
Chiang Muan (Cm)	0.42	60	780
Mae Sod (Ms)	0.4-0.5	90	400-700

## Burial History

**6.10** Generalised relationship between depth/reflectance/geothermal gradient diagram, for which surface temperature of 15°C and a surface reflectance value of 0.25% are accepted. The graph is based on the study of Suggate (1998) and is applied to the northern Thailand basins. Vitrinite reflectance data are from Ratanasthien & Kuntarote (1984) and Strogon (1994), geothermal gradient data are from both Ratanasthien & Kuntarote (1984), Thienprasert & Raksaskulwong (1984) and Curiale &



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Basin	w/d ratio	width (km)	depth (km)	source	reservoir	maturity	extent
Phrae	12	25	2.1	good	good	low-fair	good
Pua	12	12	1.0	low-fair	fair	low-fair	fair-good
Nan	12	10	0.8	low-fair	fair	low-fair	fair-good
Chiang Mai	12	35	2.9	fair-good	good	fair-good	good
Wiang Haeng	12	10	0.8	good	fair-good	fair-good	fair
Mae Chaem	12	7	0.6	good	fair-good	fair-good	low
Mae Teep	12	5	0.4	good	fair-good	fair-good	low
Mae Tun	12	7	0.6	good	fair-good	fair-good	low
Lampang	12	30	2.5	good	good	fair-good	good
Mae Sod	12	30	2.5	good	fair-good	fair-good	good
Mae Lamao	12	7	0.6	good	fair	fair-good	low
Mae Moh	12	8	0.7	good	fair-good	low-fair	fair
Thoen	12	13	1.1	low-fair	fair-good	low-fair	good
<b>Phetchabun</b>	<b>12</b>	<b>30</b>	<b>2.5</b>	<b>good</b>	<b>fair-good</b>	<b>fair-good</b>	<b>fair-good</b>
Mae Sariang	12	5	0.4	low	fair-good	low-fair	fair
<b>Fang</b>	<b>12</b>	<b>18</b>	<b>1.5</b>	<b>good</b>	<b>fair-good</b>	<b>fair-good</b>	<b>fair-good</b>
Li	12	10	0.8	good	fair-good	fair-good	fair
Chiang Muan	12	8	0.7	good	fair-good	fair-good	low
Chiang Rai	12	25	2.1	low-fair	fair-good	low-fair	fair-good
Pa Yao	12	20	1.7	low-fair	fair-good	low-fair	fair-good
Chiang Khong	12	17	1.4	low-fair	fair-good	low-fair	fair-good

Interesting basin
  Interesting basin but lack of data
  Producing basin










## Conclusion (1)

- Northward moving of Indian to Eurasian Plates has been a major cause in oblique extension during Mid Tertiary.
- Basement fabric and its orientation also play an important role during the period of extension.
- Mild inversions have been seen on most seismic sections; very gentle angle anticline and some onlap feature, this may be affected by the W-NW moving of Pacific and Australian Plates during Late Tertiary. There are also seen in Mae Moh, Mae Tha and Phrae basins.
- It is not easy to explain the origin of the basin by any single model. It is sometimes depended on basin location related to major faults and orientation of base rocks underlain the basins.

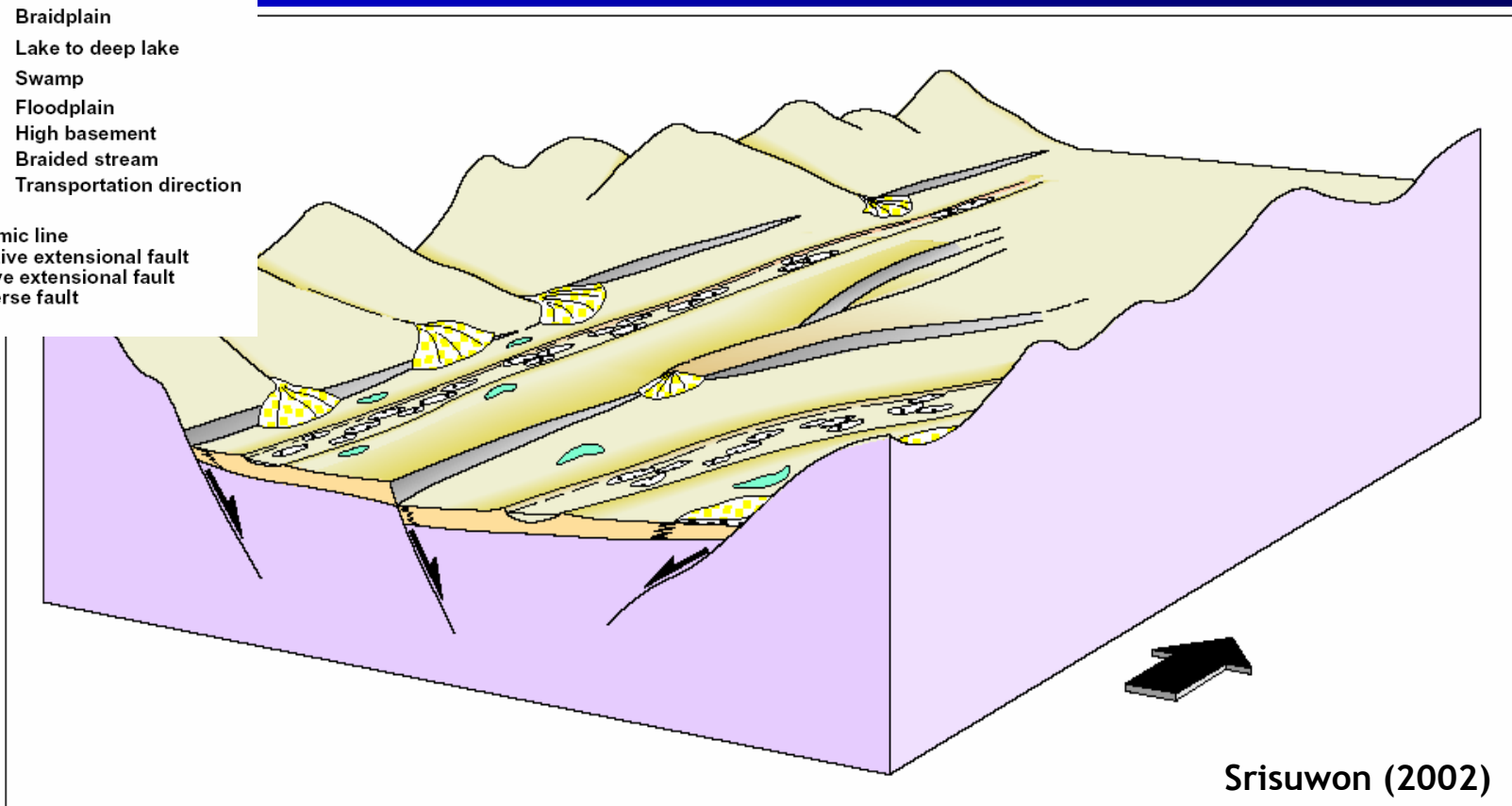
## Conclusion (2)

- Most large Tertiary basins are still interesting for petroleum potential where lacustrine can be developed during the rift fill stage and buried deep enough to reach the oil window. However, the volume of remaining source rocks is another factor to be considered.
- Original shape of most small and shallow basins do not mean the same as seen in present day. At least 450 m up to 1,500 m have been eroded during Mid Miocene and possibly Pliocene. Different amount of lost section would be related to each inherit fabric and location.
- Fractured basement reservoir cannot be ruled out.
- A good database of source rocks in different ages over the country is on the plan.

symbols














-  Alluvial fan
-  Braidplain
-  Lake to deep lake
-  Swamp
-  Floodplain
-  High basement
-  Braided stream
-  Transportation direction
  
-  Seismic line
-  Inactive extensional fault
-  Active extensional fault
-  Reverse fault
-  Fold

## Early Rift Fill Stage

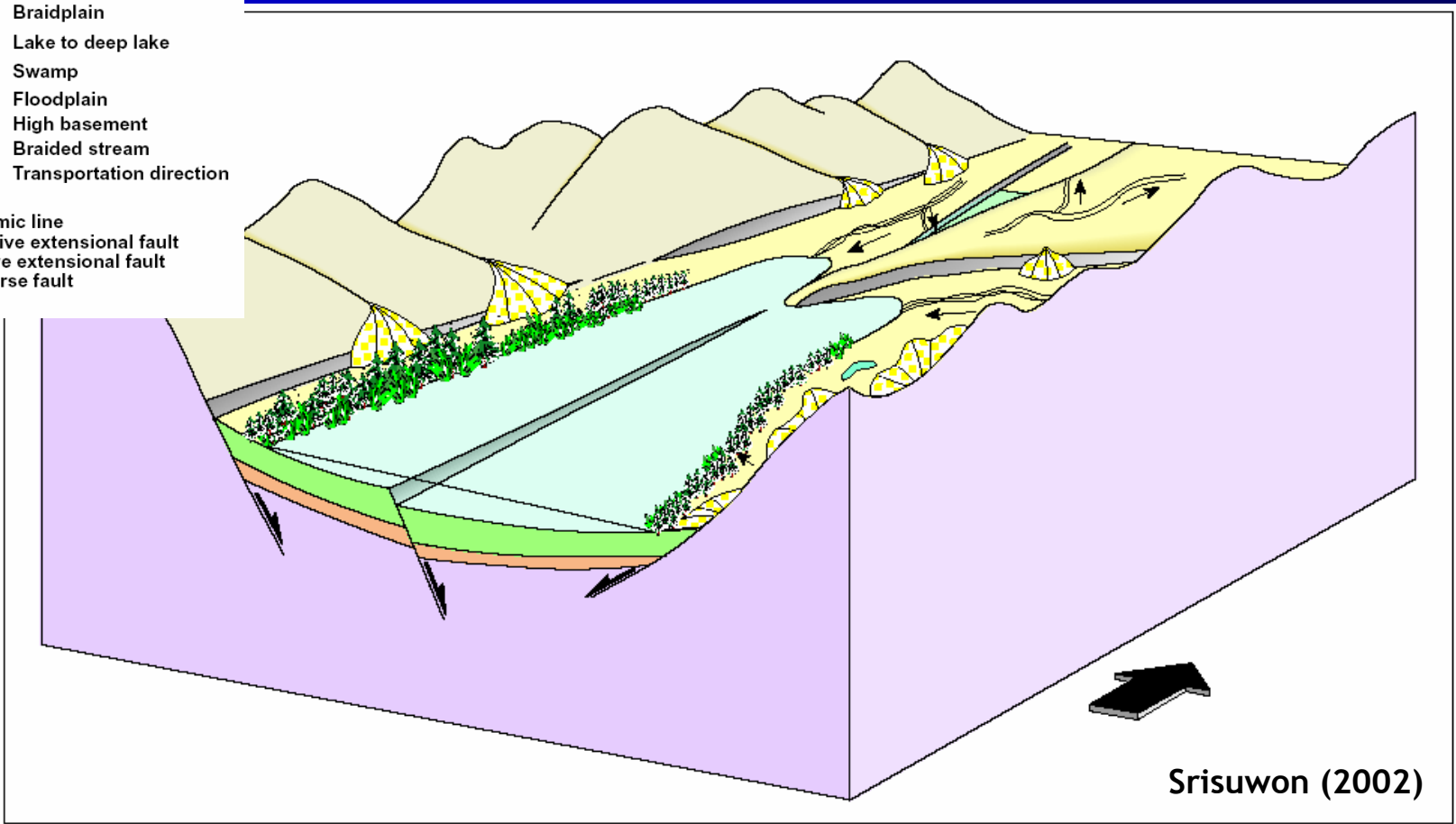


**Figure 6.3b** Oblique 3D visualization showing an early stage of development of the Phrae Basin. High basement ridge forms in the central part of the basin where the main fault is segmented. Right overstepping and sinistral sense of movement along this major fault causes building up the basement high and separates the Phrae

symbols

-  Alluvial fan
-  Braidplain
-  Lake to deep lake
-  Swamp
-  Floodplain
-  High basement
-  Braided stream
-  Transportation direction
  
-  Seismic line
-  Inactive extensional fault
-  Active extensional fault
-  Reverse fault
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






## Rift Fill Stage



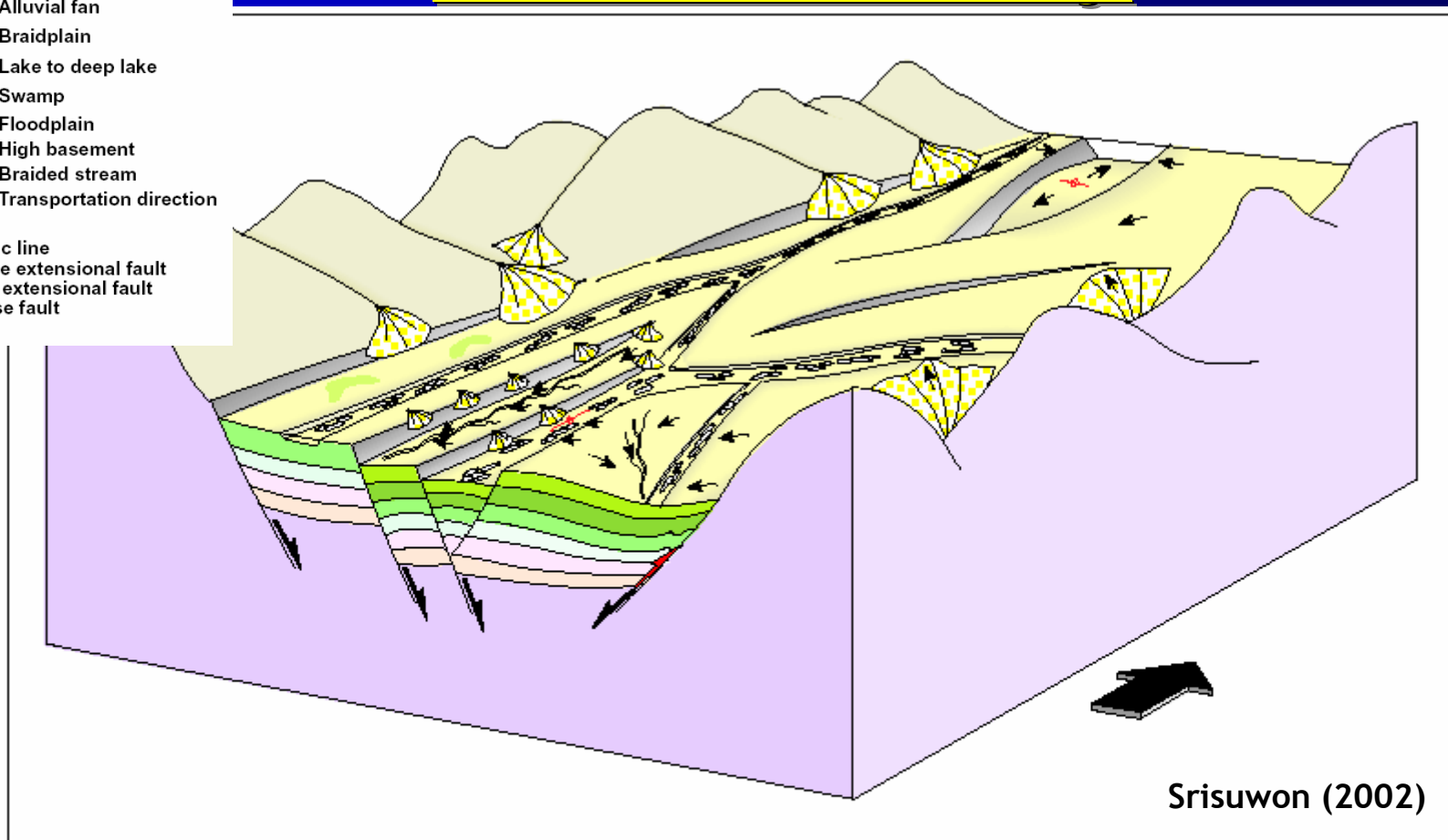
Srisuwon (2002)

**Figure 6.4b** Oblique 3D visualization showing an early to middle stage (Unit D) of development of the Phrae Basin. Lacustrine facies is dominated in the western part of the Phrae sub-basin while the eastern part, lacustrine is involved by alluvial fan and braided stream facies. The Rong Kwang sub-basin in the north is also

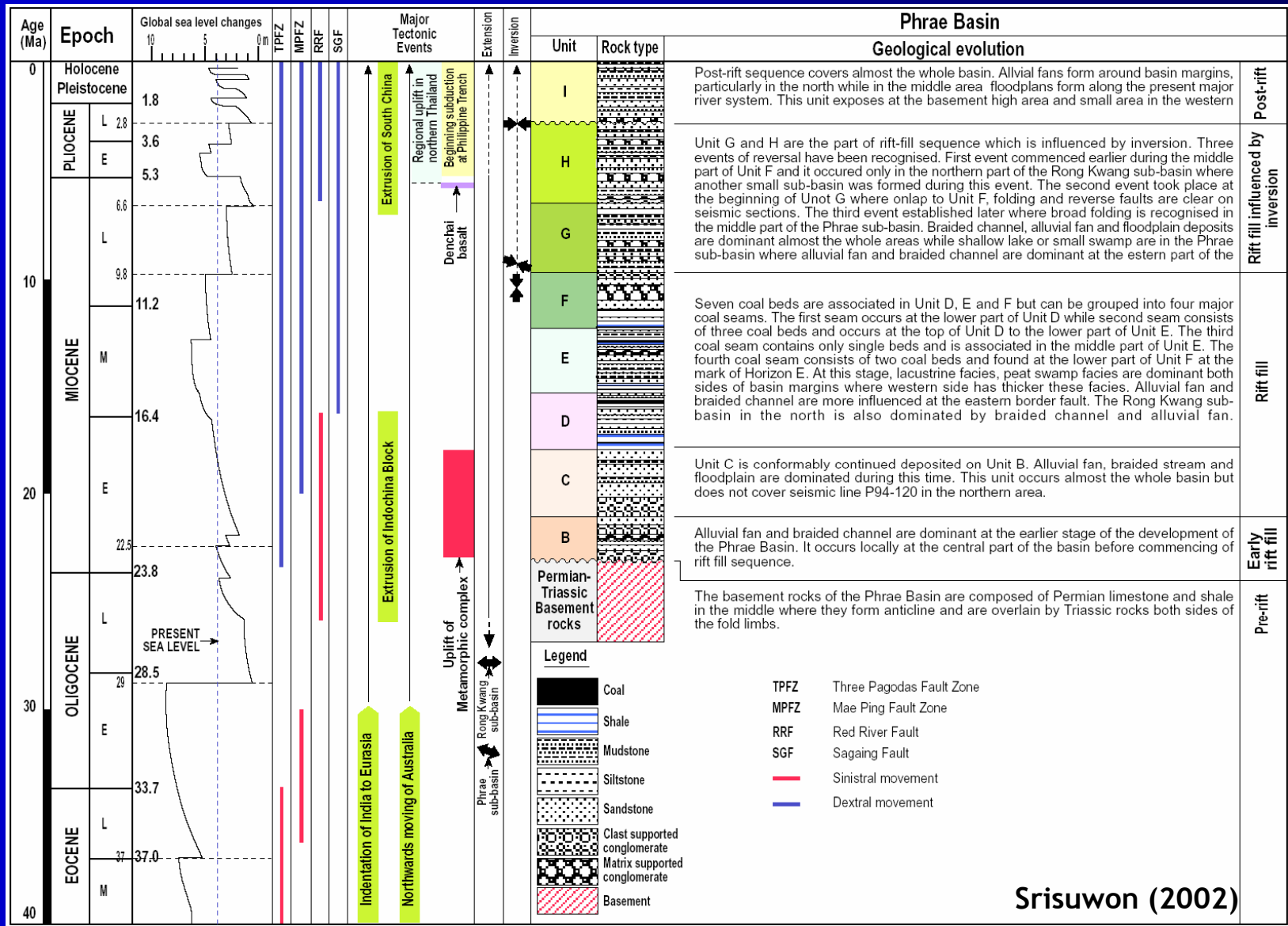
symbols

-  Alluvial fan
-  Braidplain
-  Lake to deep lake
-  Swamp
-  Floodplain
-  High basement
-  Braided stream
-  Transportation direction
  
-  Seismic line
-  Inactive extensional fault
-  Active extensional fault
-  Reverse fault
-  Fold

## Rift Fill with Inversion Stage



**Figure 6.7b** Oblique 3D visualization showing the development of the Phrae Basin during late stage when the second event inversion is taken place which is caused in forming broad anticline in the main Phrae sub-basin. At this stage the whole parts are dominated by alluvial fan and braided stream facies. Sediments in the central areas are transported to both sides of the broad anticline and deposited into the



## Acknowledgement

- Big thanks to all executives for their supports to make this event be possible.
- Friends from the Mineral Fuels Technical Bureau (Petroleum Assessment Group) for their fruitful discussions.
- Special thanks to Khun Somchai Poom-Im, my first trainer when I was a young geologist at the Coal Section (DMR) many years ago.

**Thank You**