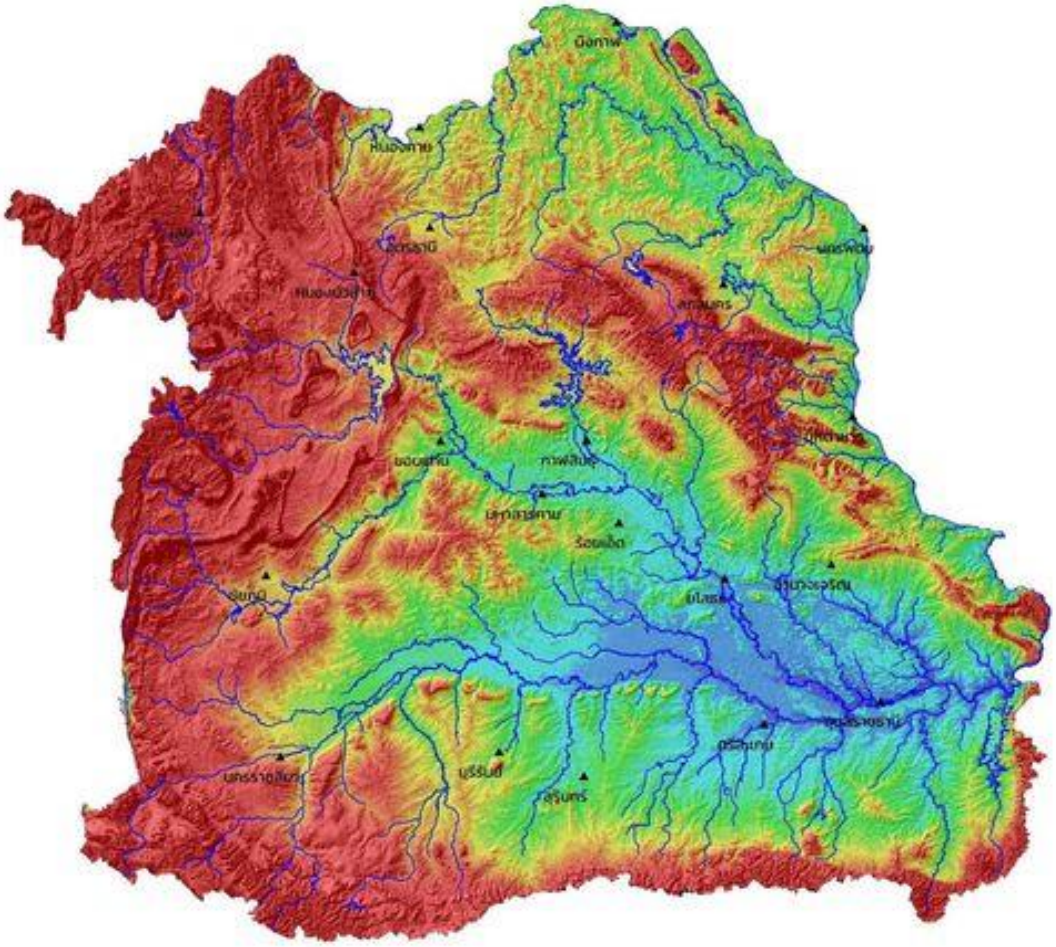
Is Geology of NE Thailand so Simple?

ธรณีวิทยาอีสาน : ความยุ่งยากในความเรียบง่าย

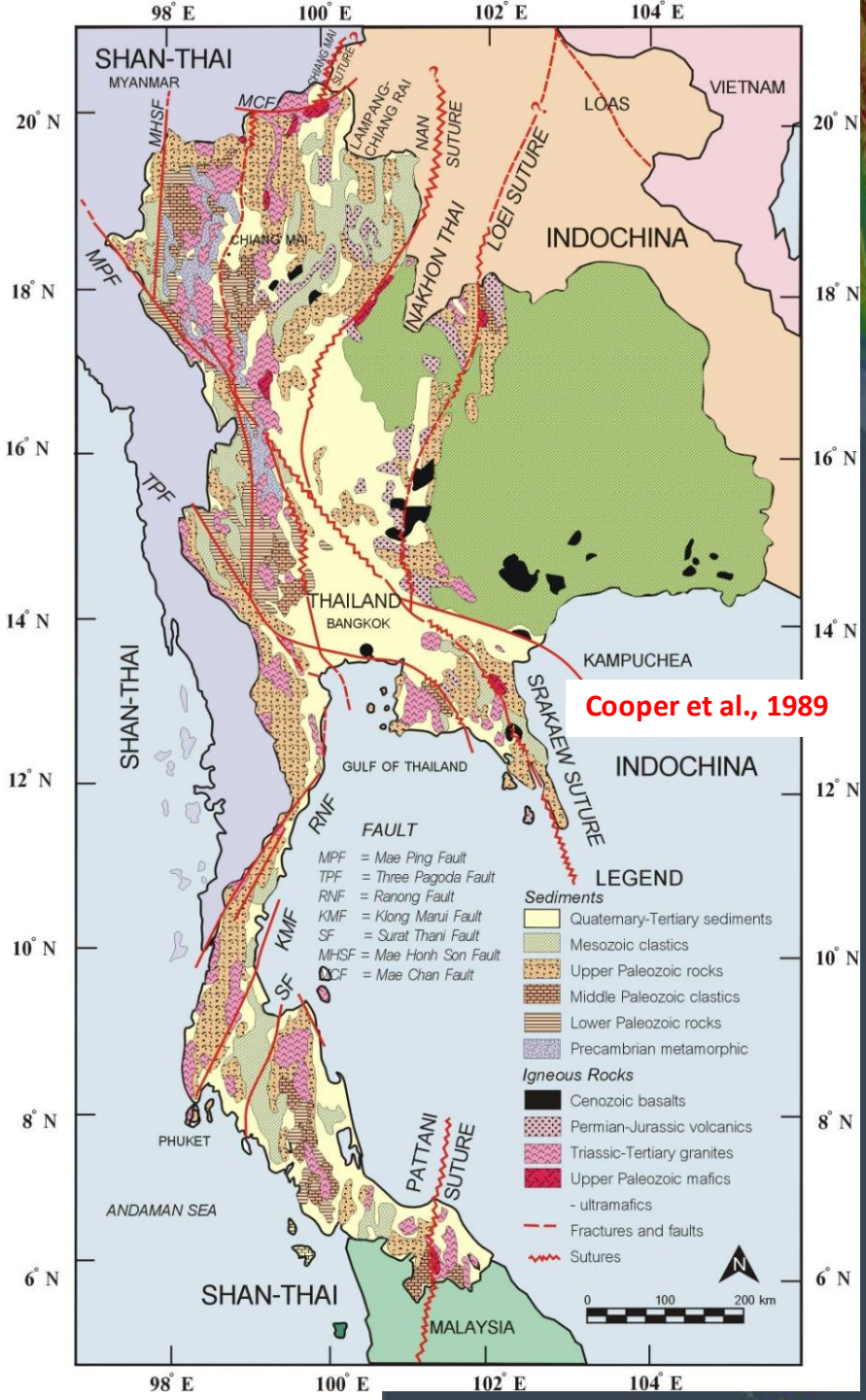


Department of Mineral Resources

Nares Sattayarak : 10 January 2024

Content

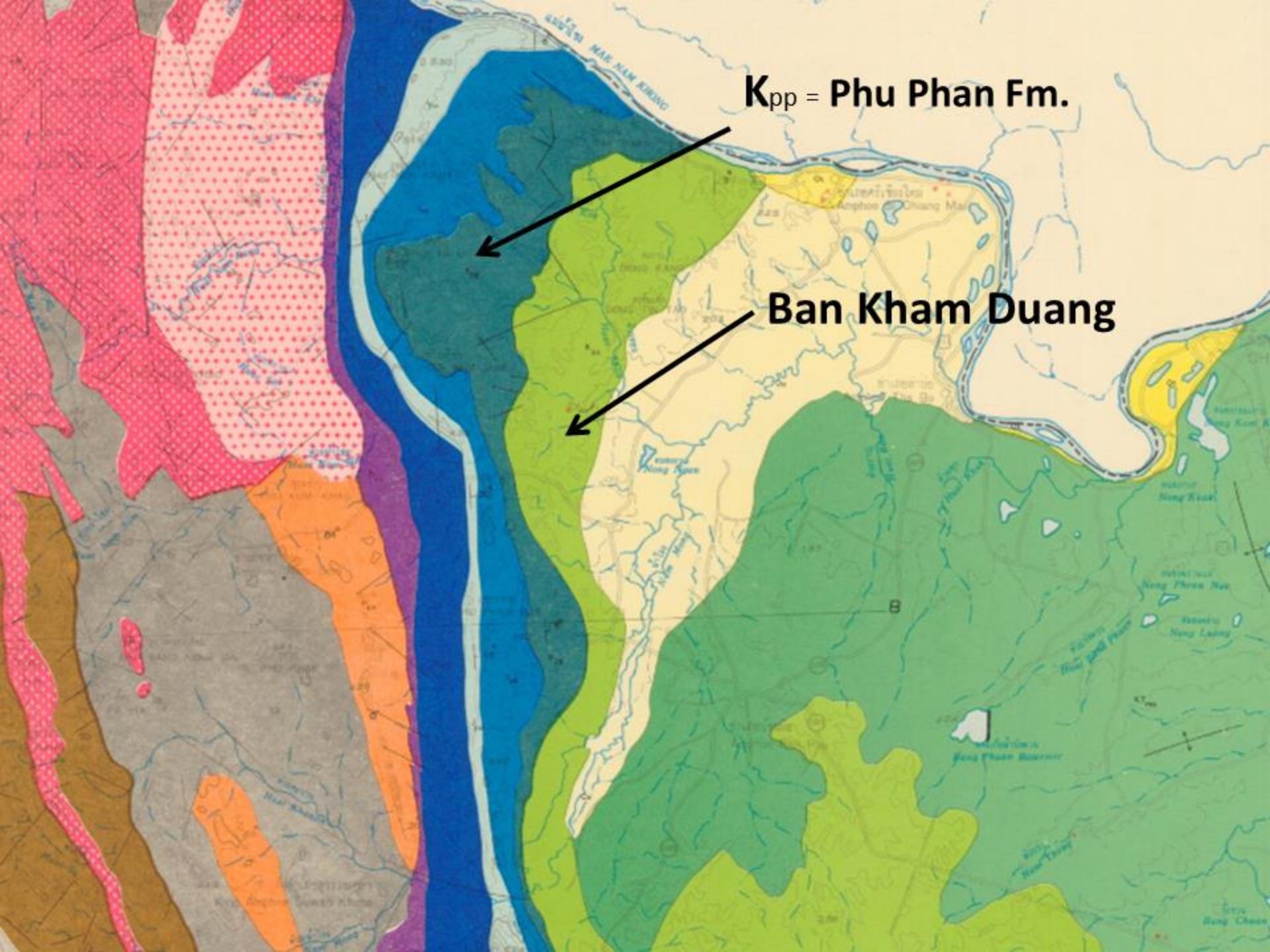
Content

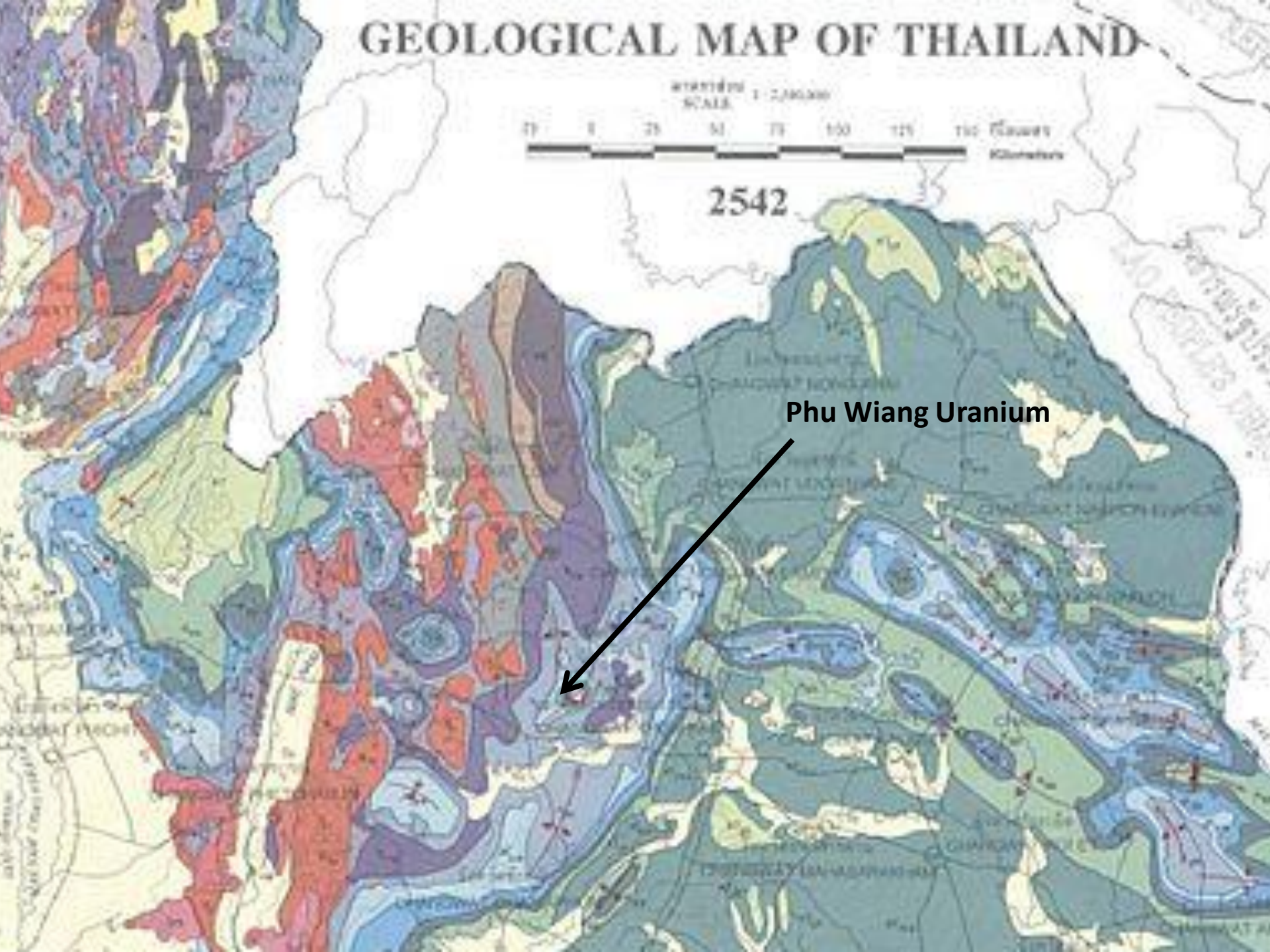


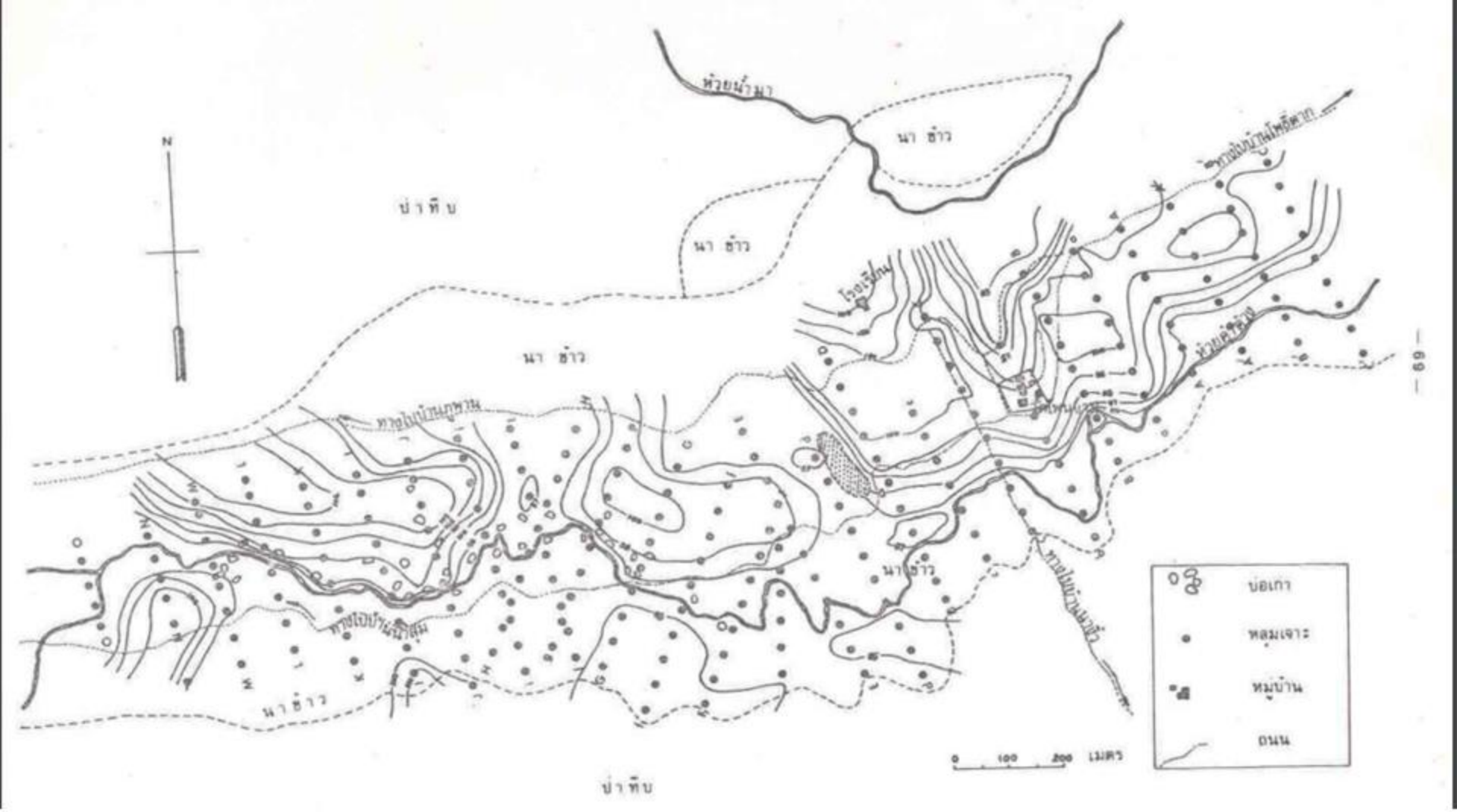
Cooper et al., 1989

Northeastern Thailand & The so-called Khorat Plateau


บ้านคำด้วง อ.บ้านผือ จ.อุดรธานี
พ.ศ. 2556
อุดรธานี
OPEN UDON
เมืองข่าวเมืองอุดร
พบแร่ ทองคำขาว ตำบลคำด้วง อ.บ้านผือ จ.อุดรฯ


K_{pp} = Phu Phan Fm.
Ban Kham Duang


GEOLOGICAL MAP OF THAILAND
2542
Phu Wiang Uranium



แผนที่แสดงแหล่งแร่ทองคำ และทองคำขาว
บ้านคำด้วง อ.บ้านผือ จ.อุดรธานี
อมร เมธีกุล, 2506

จากผลการเจาะสุ่มสำรวจพบ
ทองคำ 61.58 กิโลกรัม
ทองคำขาว 18.96 กิโลกรัม

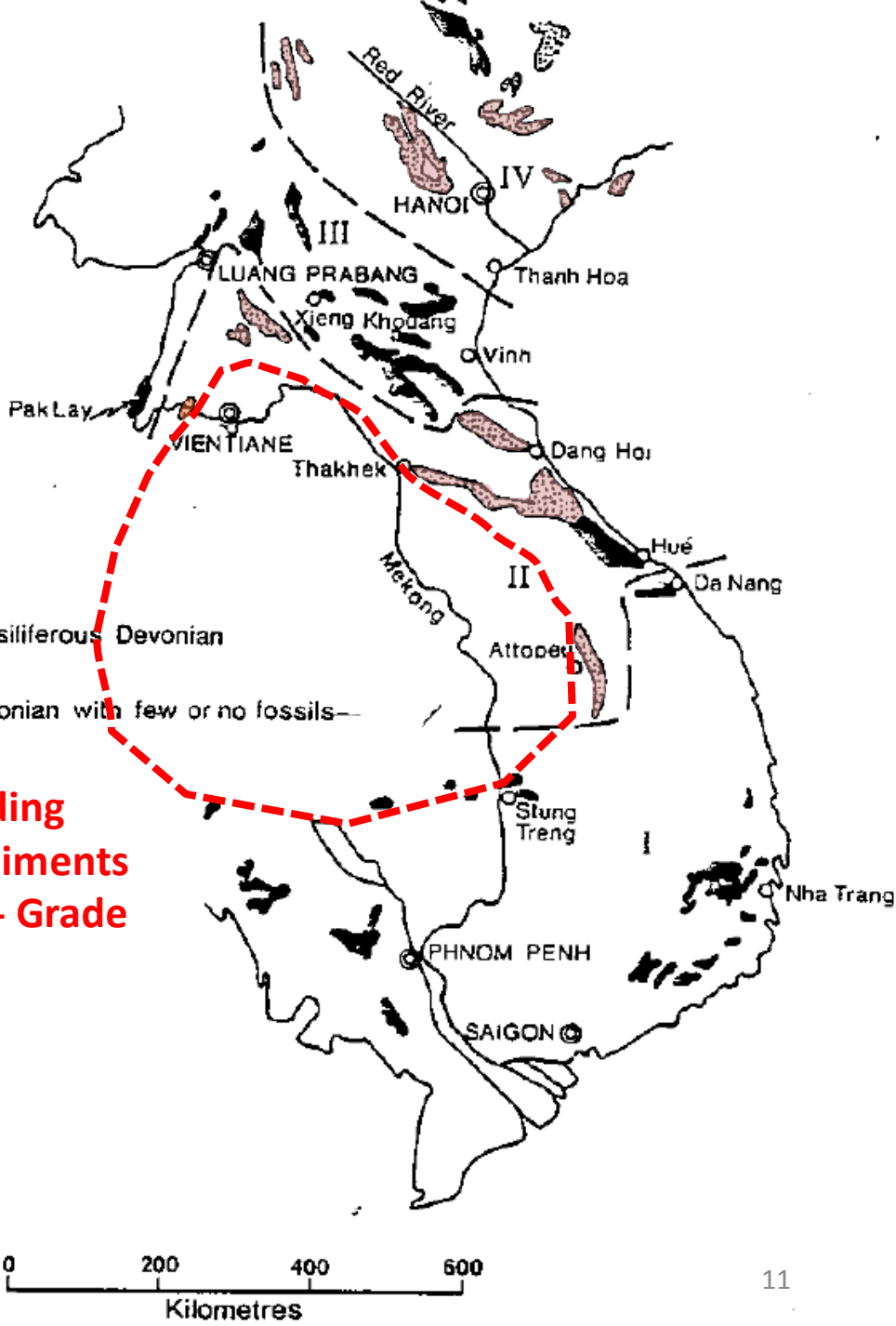

K_{pp} = Phu Phan Fm.
Ban Kham Duang
Na Khang Lst.
แผนพัฒนาเศรษฐกิจสังคมแห่งชาติ
ฉบับที่ 4 (2520-2524)

Content

Workman, 1972

Geology of Laos, Cambodia/ South Vietnam and the eastern part of Thailand a review:

Institute of Geological Sciences Report 19; 49 p.

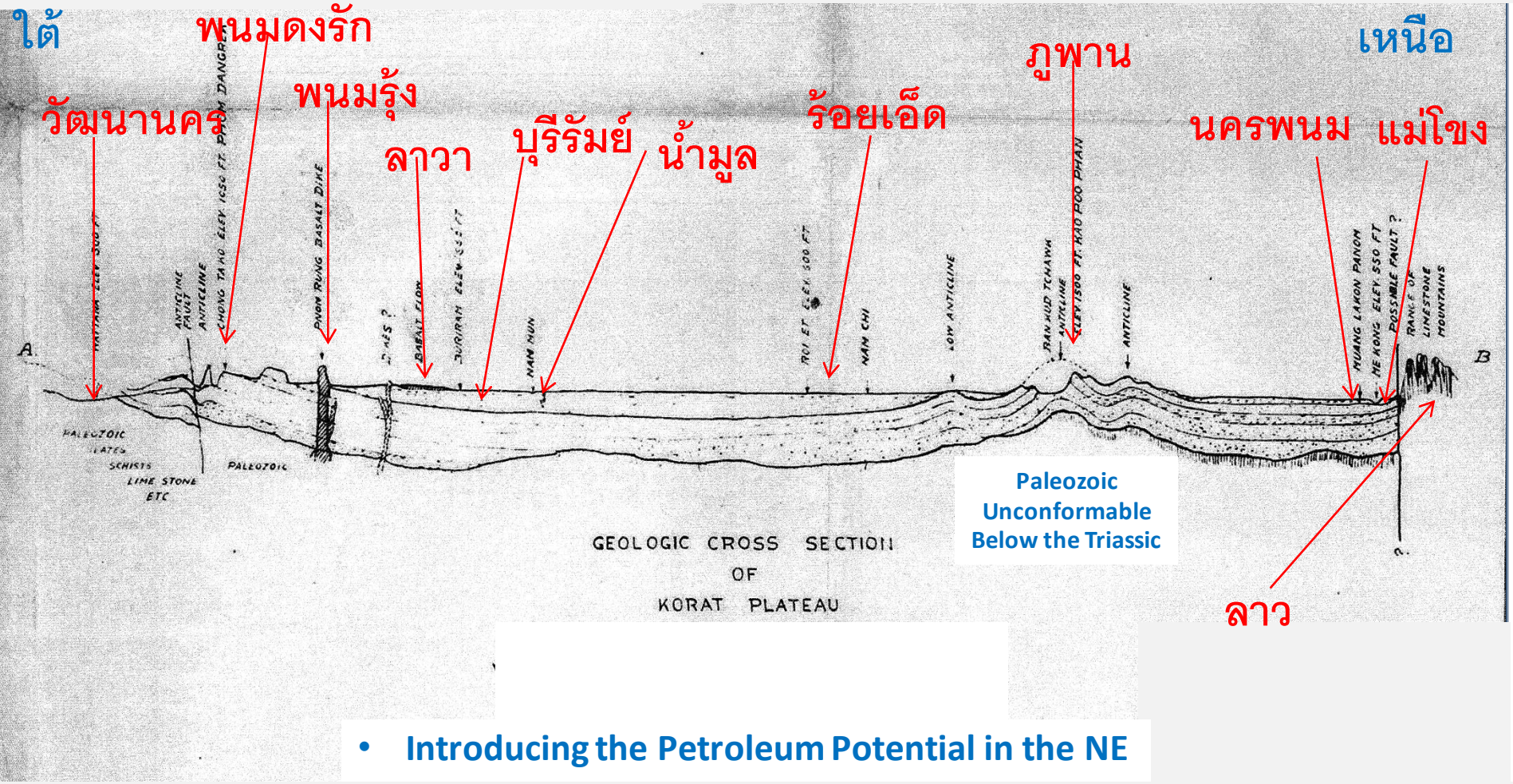


Indochina Terrane

- **Flat Land with Board and Simple Folding**
- **Surrounded by Devonian Marine Sediments**
- **Floored by Crystalline Rocks or High - Grade Metamorphic Rocks**

- **Decreasing in Petroleum Potential**

Wallace Lee, 1923



Paleozoic Unconformable Below the Triassic

- Introducing the Petroleum Potential in the NE

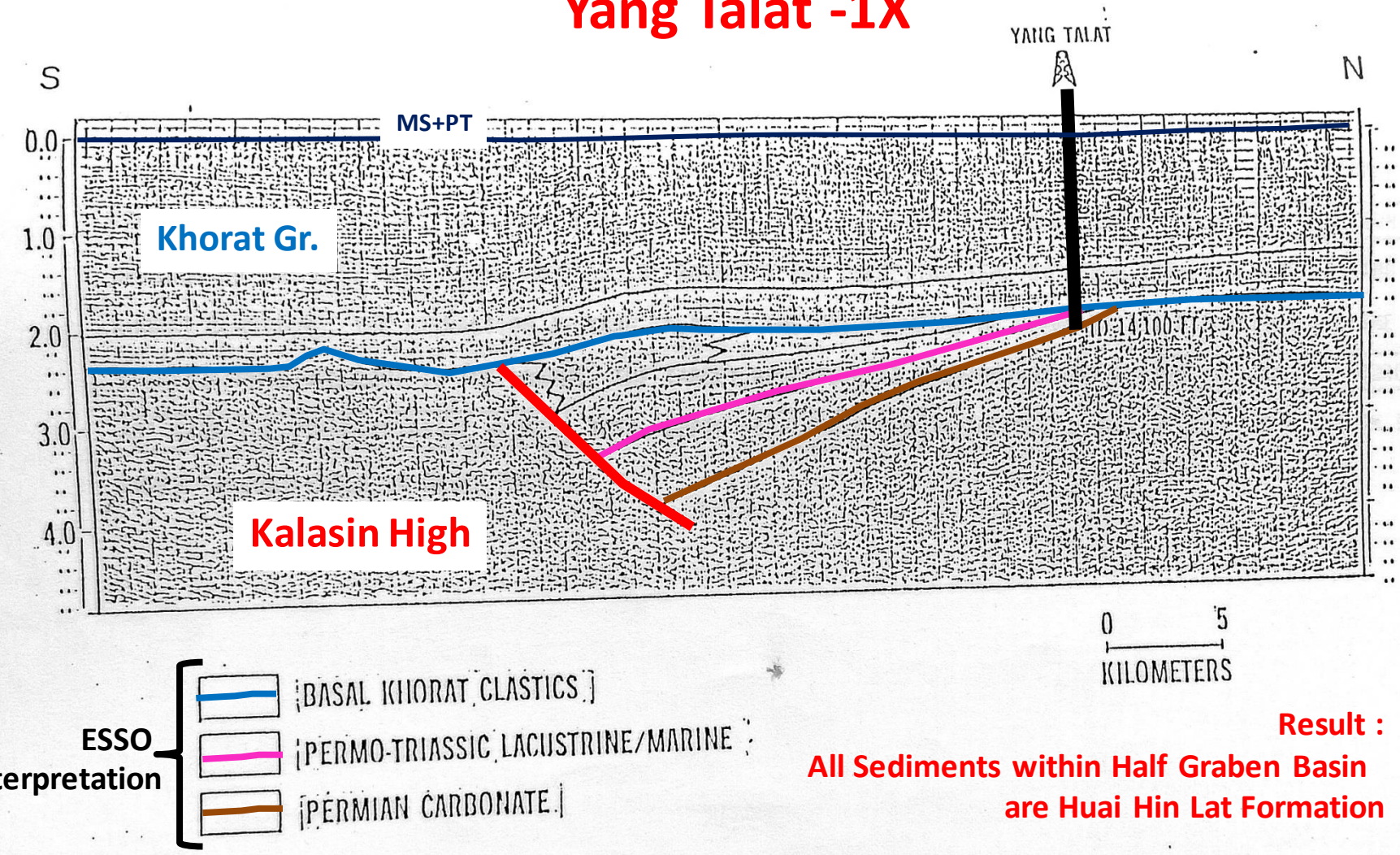
การเทียบสัมพันธ์ของหมวดหินที่มีอายุในมหายุคพาลีโอโซอิกตอนล่างในประเทศไทย

NE?

System \ Region	Brown *et al.* (1951)	Javanaphet. (1969)		Westhern Highland	Northern Highland	Southern Peninsula	Eastern Gulf	The Central Plain	Loei–Petchabun Ranges	The Khorat Plateau
Carboniferous	Kanchanaburi Series	Tanaosi Gr.	Kaeng Krachan Fm.	Mae Hong Son Fm.	Phrae Fm.	Kaeng krachan Fm.	Dan Lan Hoi Gr.(?)		Wang Saphung Fm.	
					Dan Lan Hoi Gr.					
Devonian			Kancha-naburi Fm.	Thong Pha Phum Gr.	Sukhothai Gr.	Thong Pha Phum Gr.	Sukhothai Gr. (?)			Pak Chom Fm.
Silurian										
Ordovician	Thung Song Ls.	Thung Song Gr.		Thung Song Gr. (?)		Thung Song Gr.	Thung Song Gr. (?)			
Cambrian	Phuket Series	Tarutao Gr.		Tarutao Gr. (?)		Tarutao Gr.	Tarutao Gr. (?)			
Pre-Cambrian				Lan Sang Gneiss Complex		Lan Sang Gneiss Complex (?)				

Wongwanich et al., 2002

Yang Talat -1X

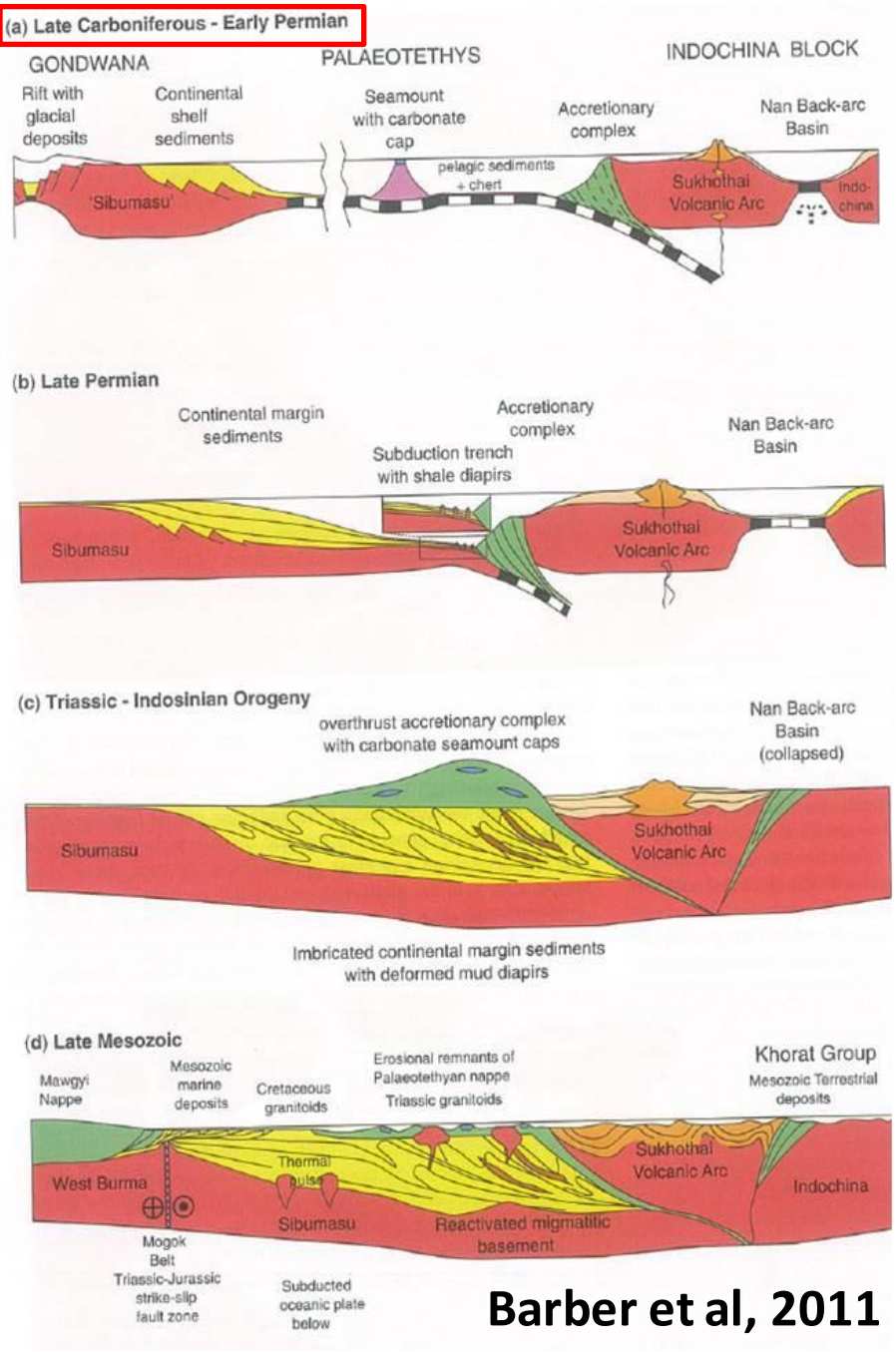


Result :
All Sediments within Half Graben Basin are Huai Hin Lat Formation

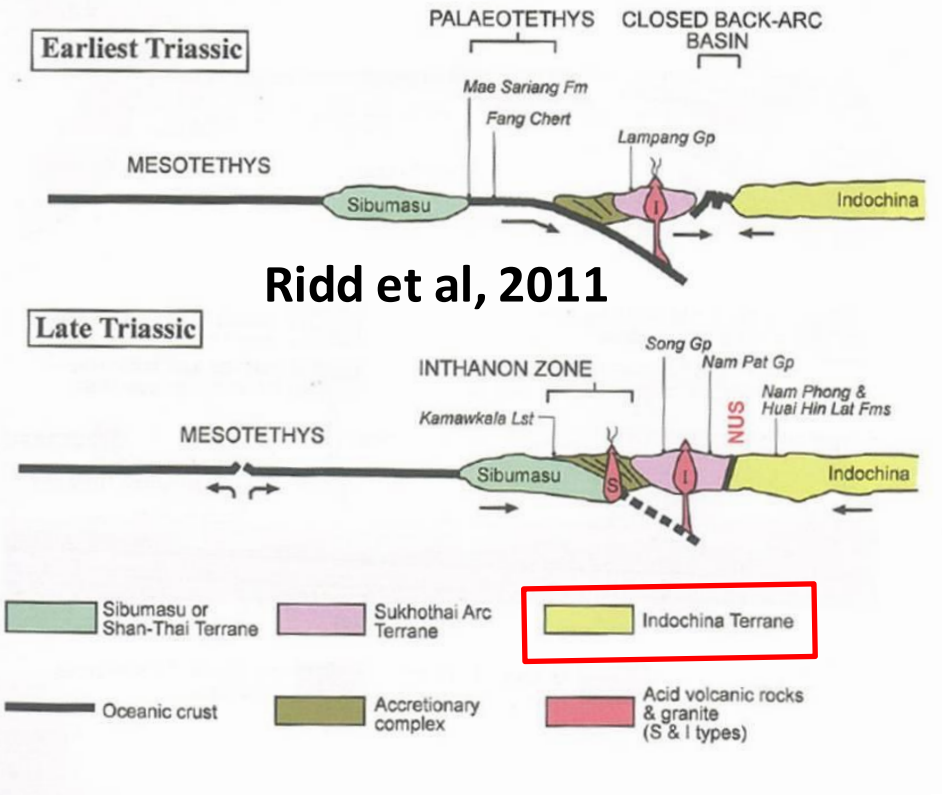
Basement are 329± 3 Ma Granite

Yang Talat -1X well Located in Yang Talat, Kalasin

Content



Barber et al, 2011

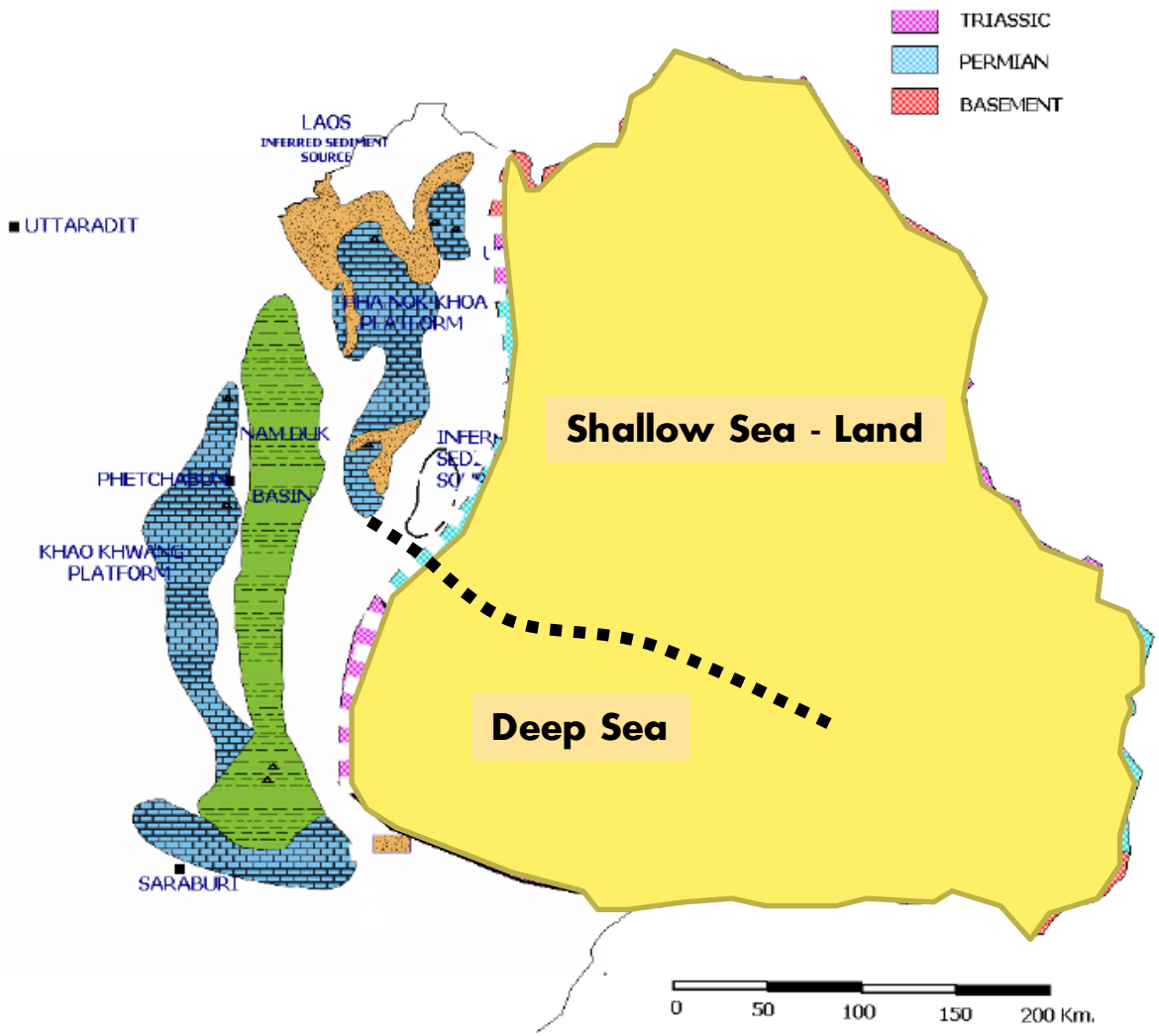


Ridd et al, 2011

Where were the Eastern margin of Late Paleozoic Seas

Most Farang implied ISAN Sea as the western rim of Indochina Block

Combination between maps of Permian paleogeographic provinces and Permo-Triassic subcrop



Left side:
Permian paleogeographic provinces: the Khao Khwang platform, the Nam Duk basin and the Pha Nok Khao platform in their modern position (Wielchowsky & Young, 1985).

Right side:

Nam Duk & NE Permian Sea With Triple Junction Assumption

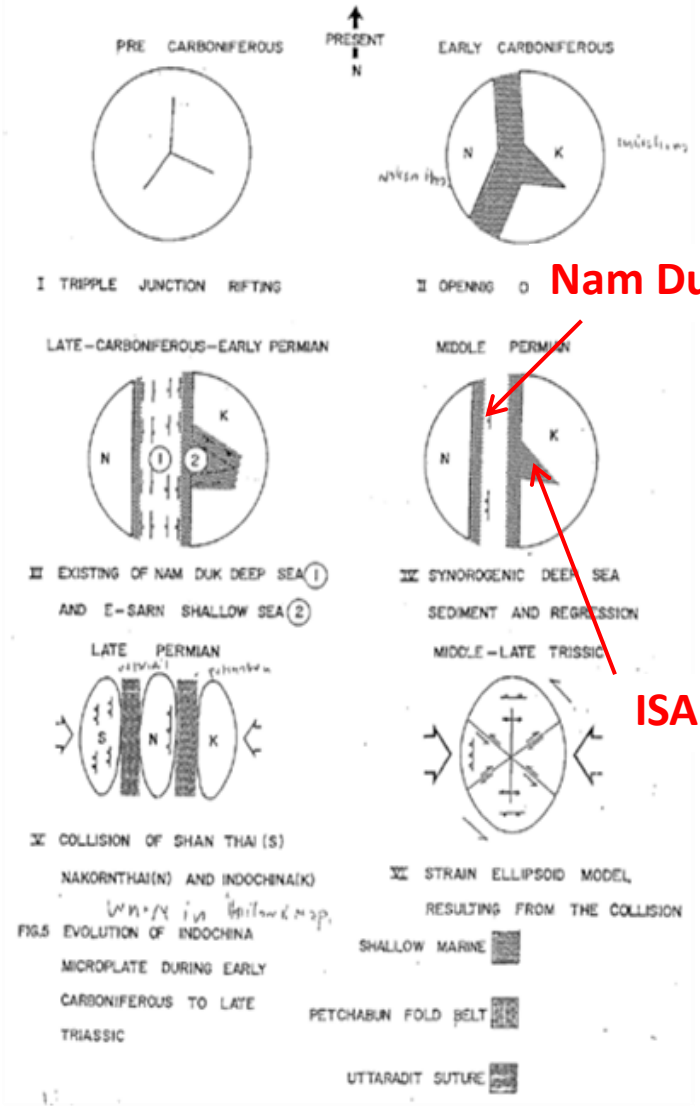
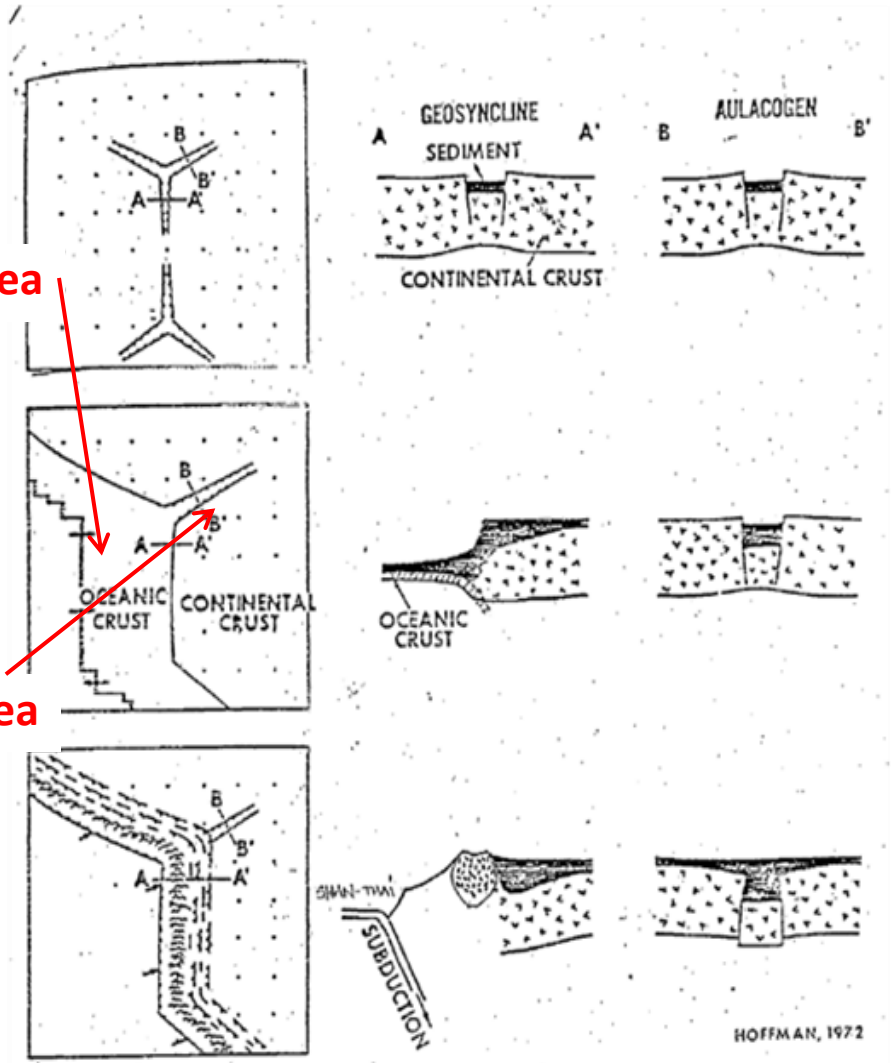


FIG.5 EVOLUTION OF INDOCHINA MICROPLATE DURING EARLY CARBONIFEROUS TO LATE TRIASSIC

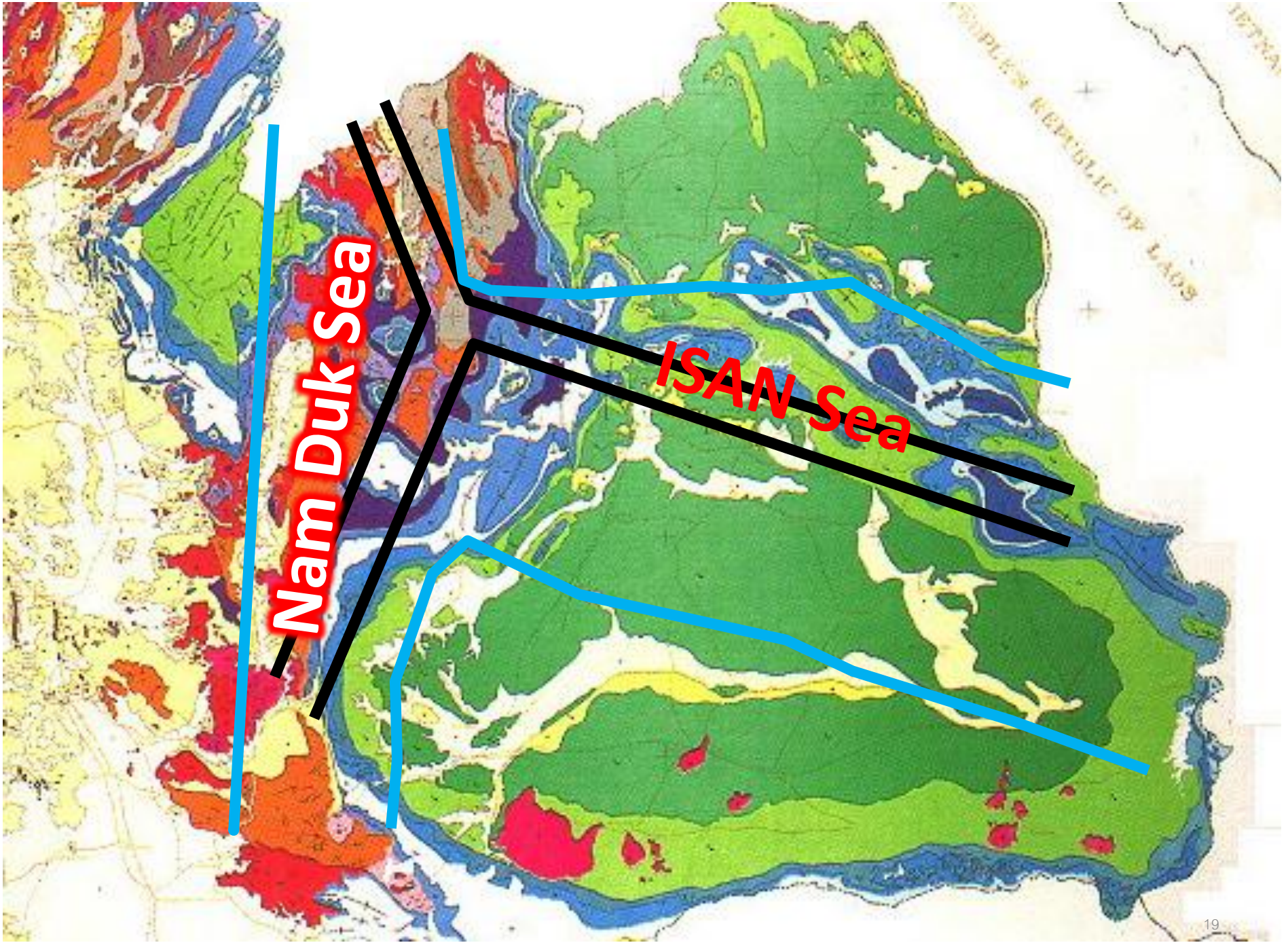
Nam Duk Sea

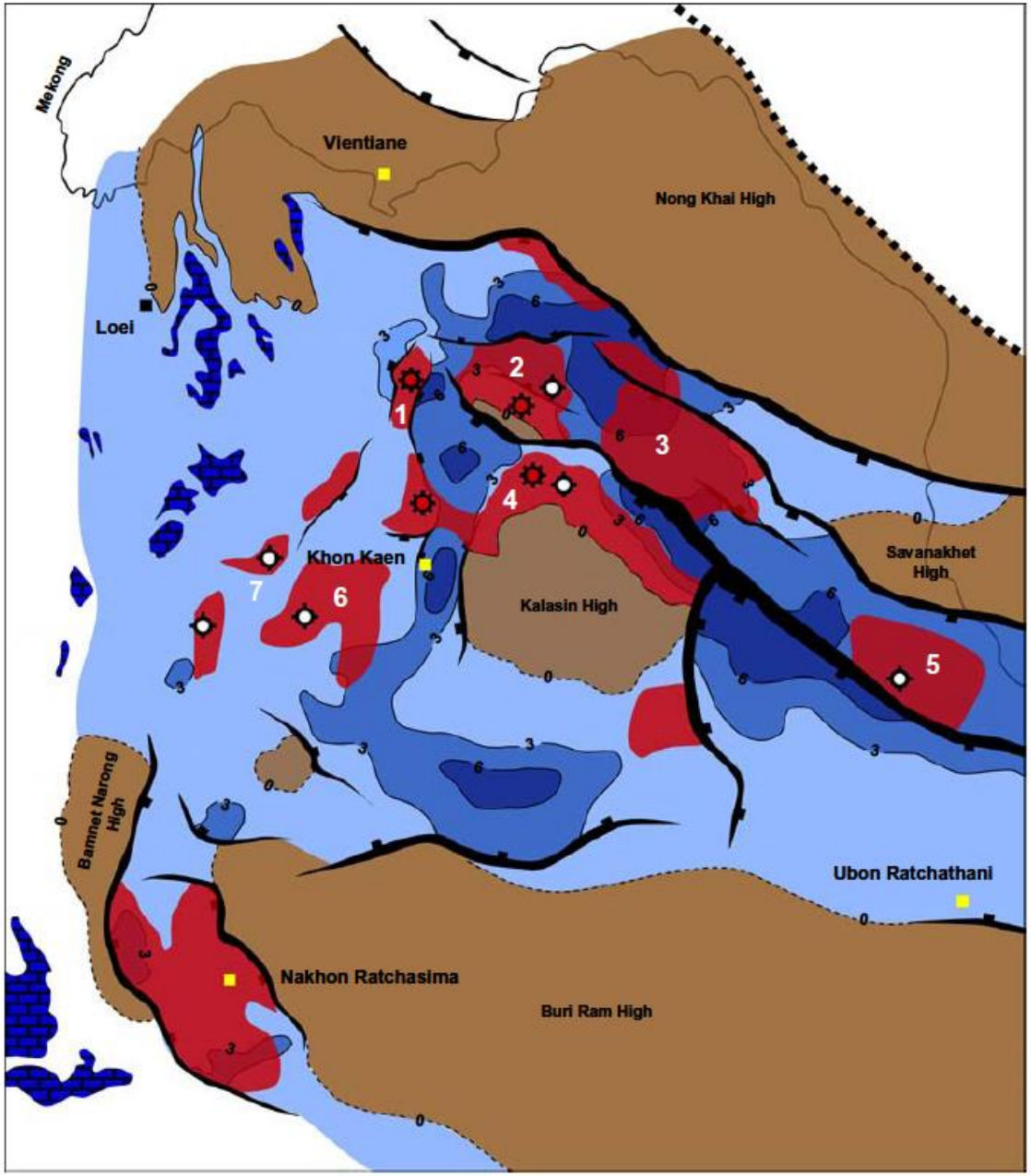
ISAN Sea



Sattayarak et al, 1989

Harding and Henshaw,1981


Nam Duk Sea
ISAN Sea



Outcropping platform carbonates

Subsurface carbonate platform
(where undrilled inferred from seismic facies character)

1 Phu Horm carbonate platform
2 Si That carbonate platform
3 Lam Pao carbonate platform
4 Dong Mun carbonate platform
5 Non Sung carbonate platform
6 Phu Din carbonate platform
7 Dao Ruang carbonate platform

Gas well with carbonate reservoir

Dry hole penetrated carbonates

Booth and Sattayarak, 2011

Basement High

<3 km

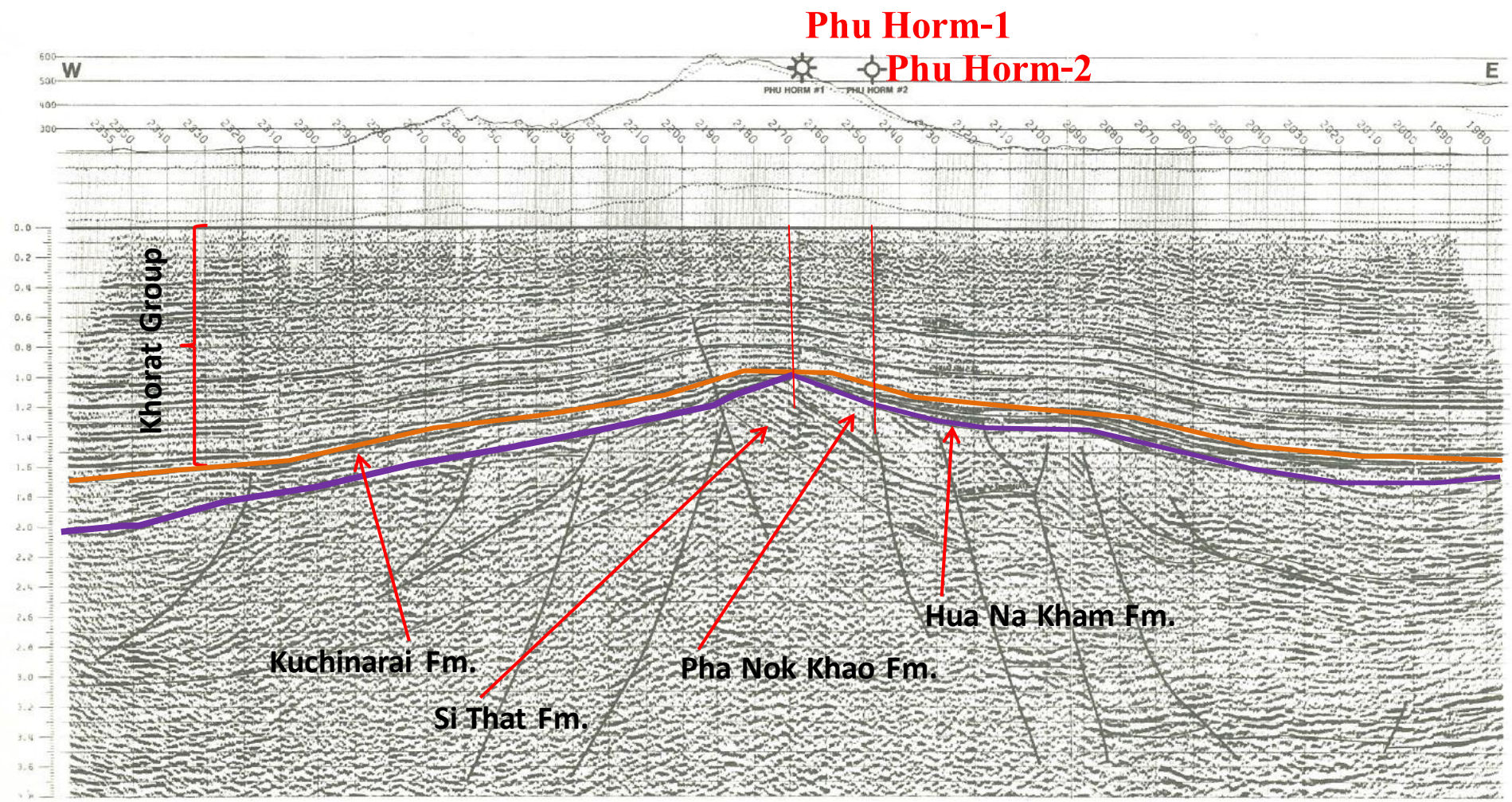
3–6 km

>6 km

Carbonate Platforms of the Pha Nok Khao Formation equivalents
(mid Lower–Middle Permian)

0 km 100

Khorat Plateau Subsurface Stratigraphy

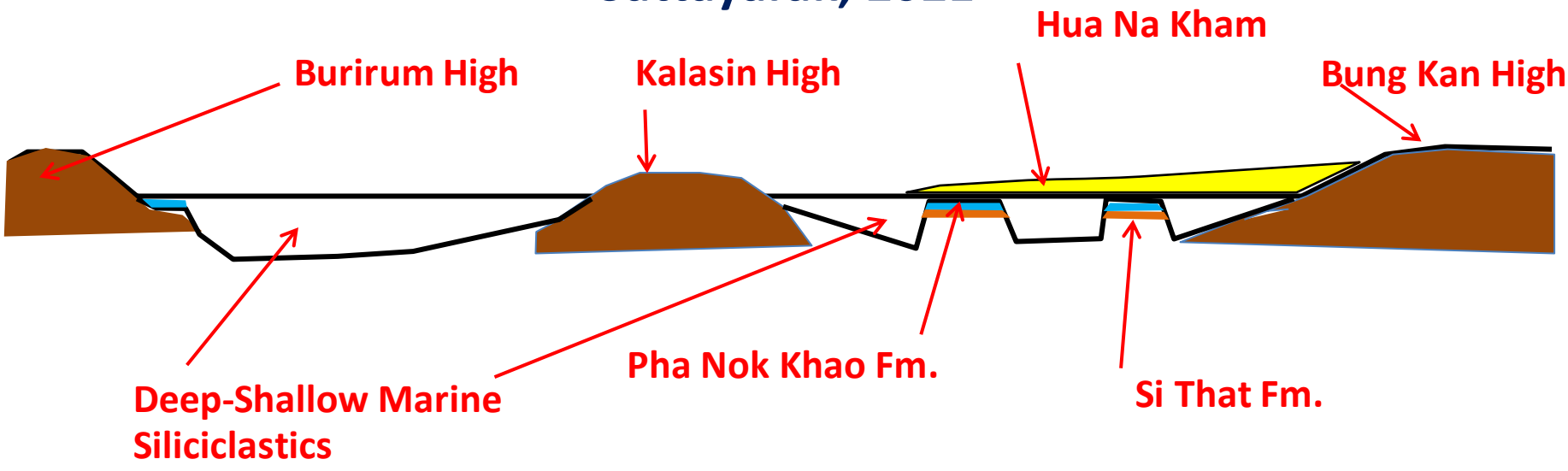


Seismic Line Across Phu Horm Gas Field, U-Don Thani

Kozar et al., 1992

Permo-Carboniferous Basins in NE Thailand

Sattayarak, 2021



Shallow Marine & Siliciclastics

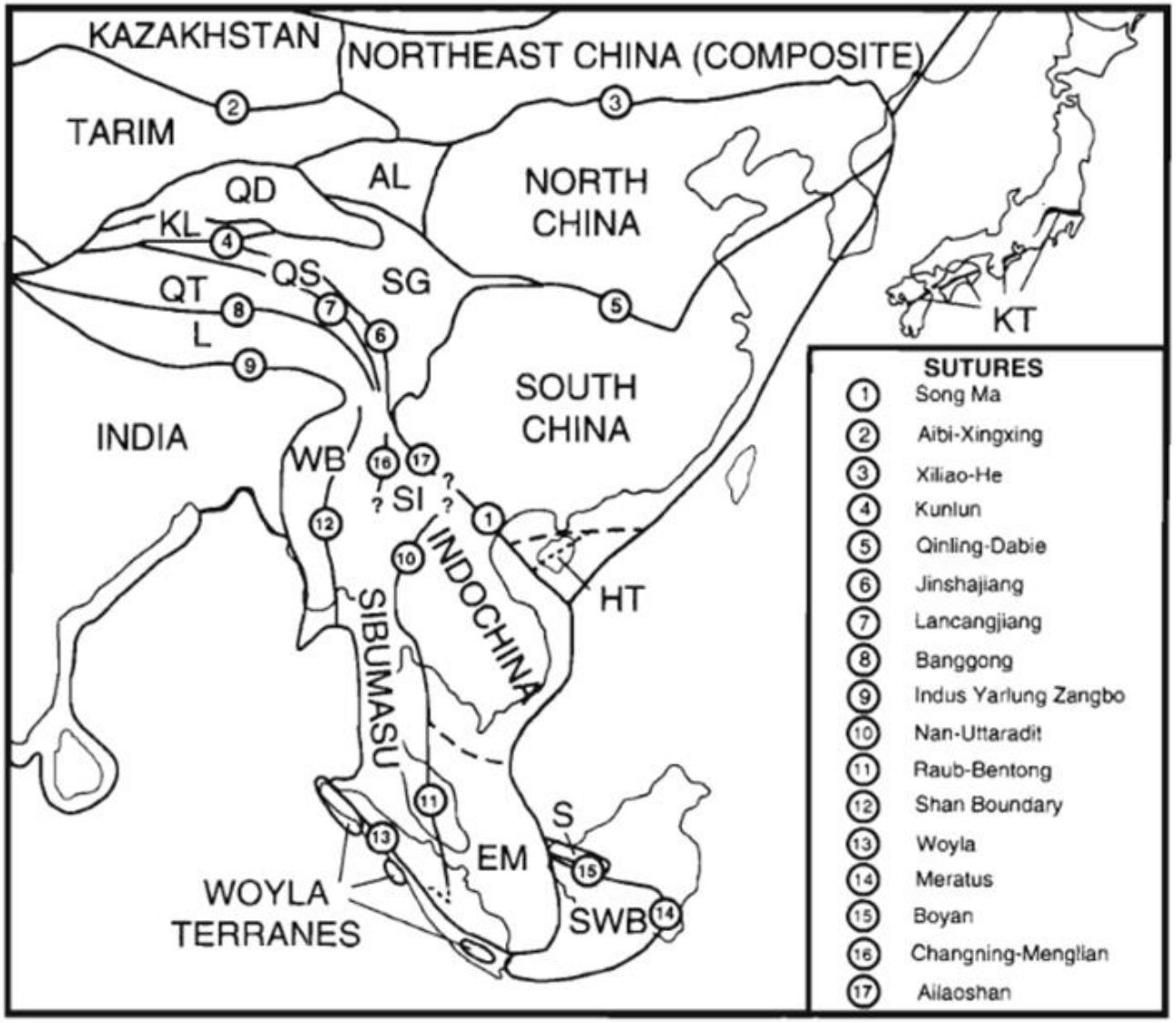
Deep Sea Sediments

Host & Graben
Back Arc Basins

Content

1. ISAN is Geologically Different from Other Parts of Thailand
2. What Kind of Rocks Lain Beneath ISAN ?
3. How Does ISAN Sea Look Like ?
4. **What Caused Indosinian Orogeny ?**
5. How Did 210 Ma Lakes Brought Up ?
6. What Type is Khorat Sedimentary Basin ?
7. Is Maha Sarakham Salt Marine in Origin?
8. What is the Extension of Phu Tok Desert ?
9. What Caused Khorat Plateau uplifted ?
10. How 16 Ma Mammal Fossils found in Khorat ?
11. Conclusion

- Q&A



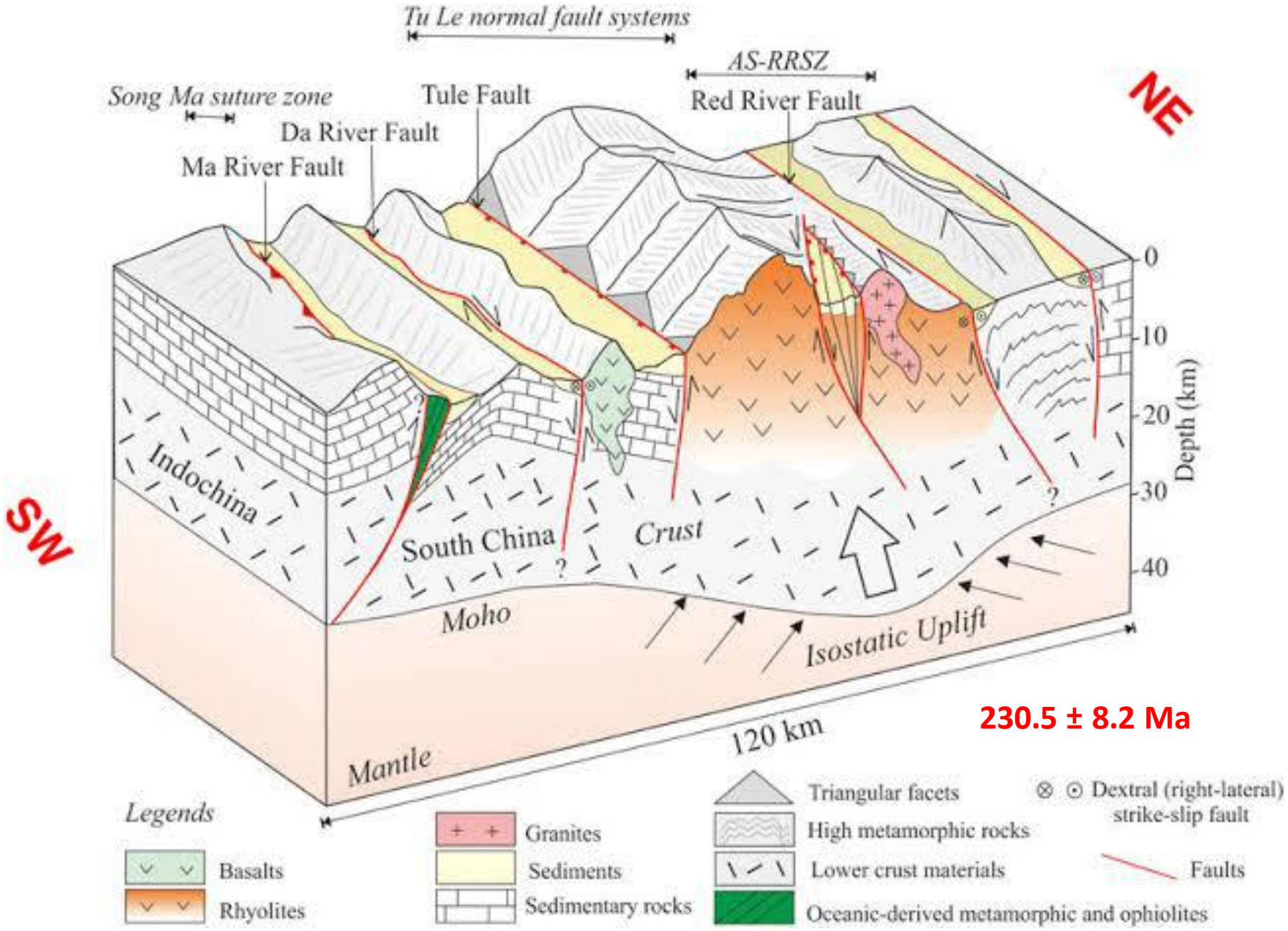
Metcalfe, 1996

Carter and Clift, 2008

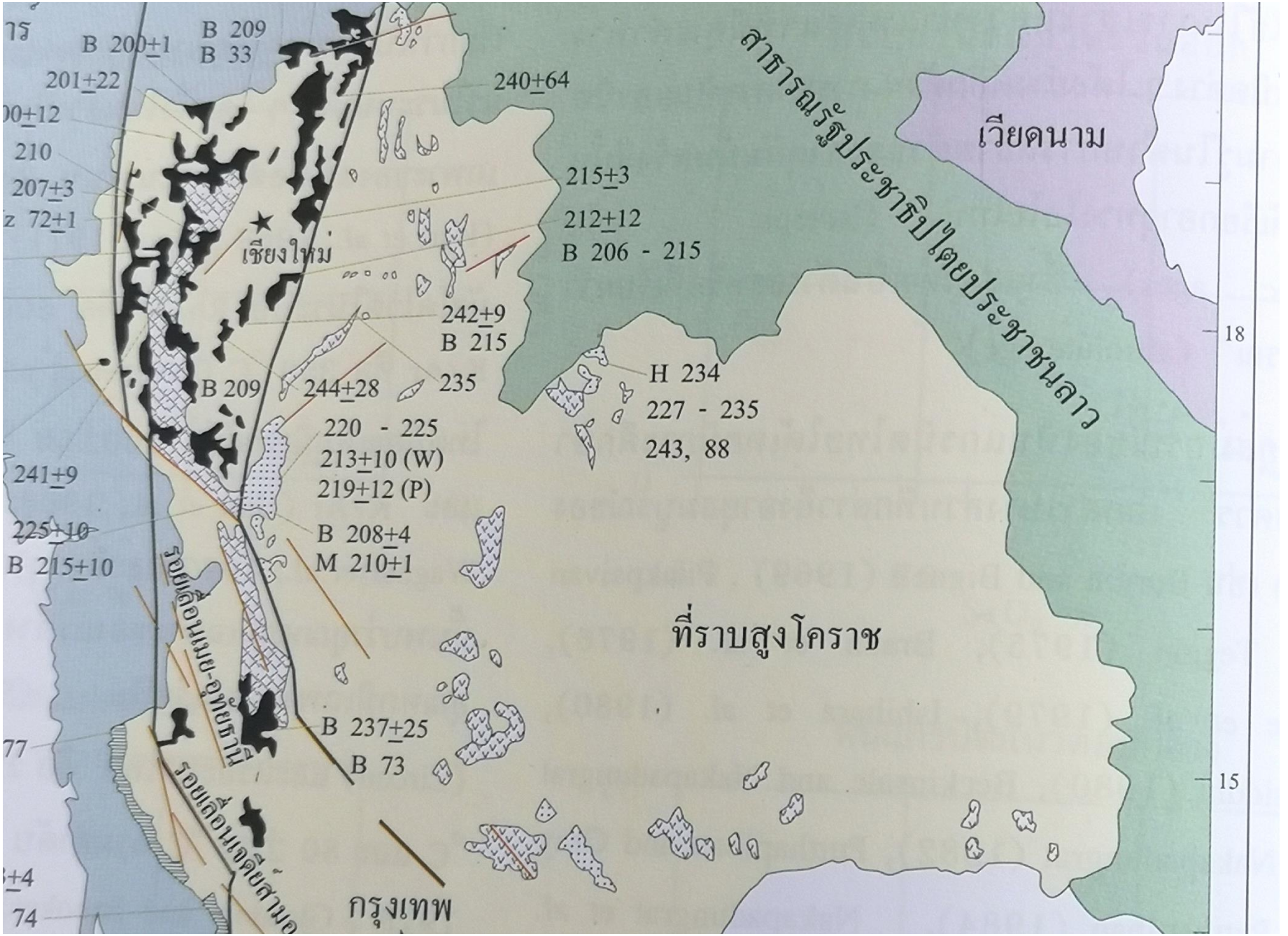
Barber et al, 2011

Ridd et al, 2011

Minezaki et al, 2018



Dinh et al, 2022



Map of Granite and Ages in the Upper Part of Thailand, DMR (1999)

Content

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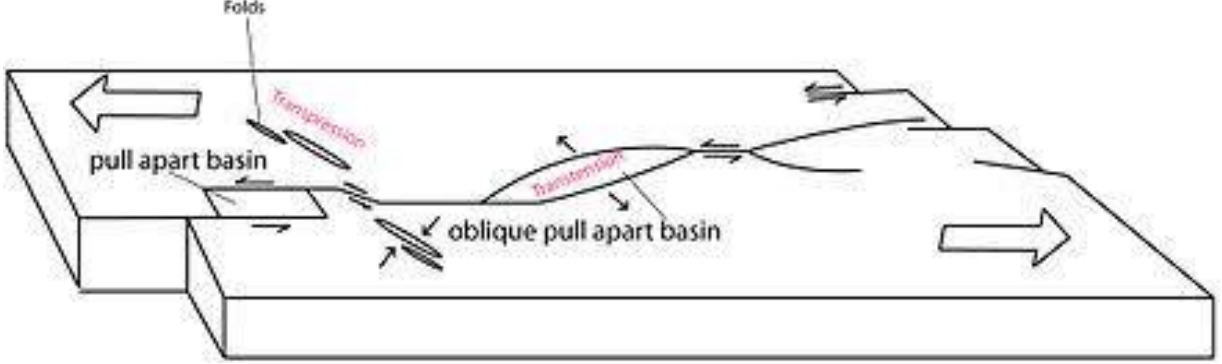
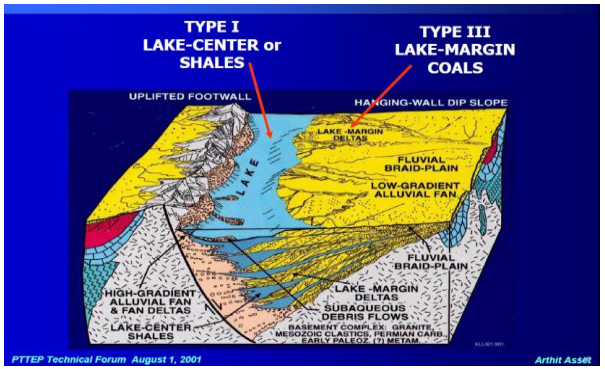
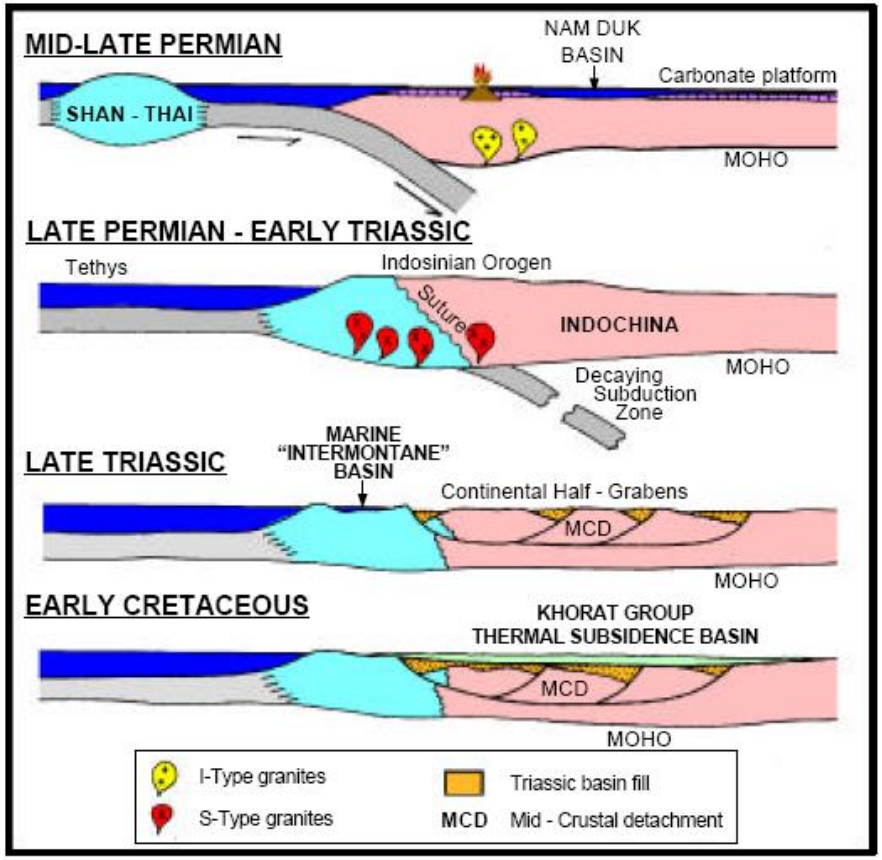
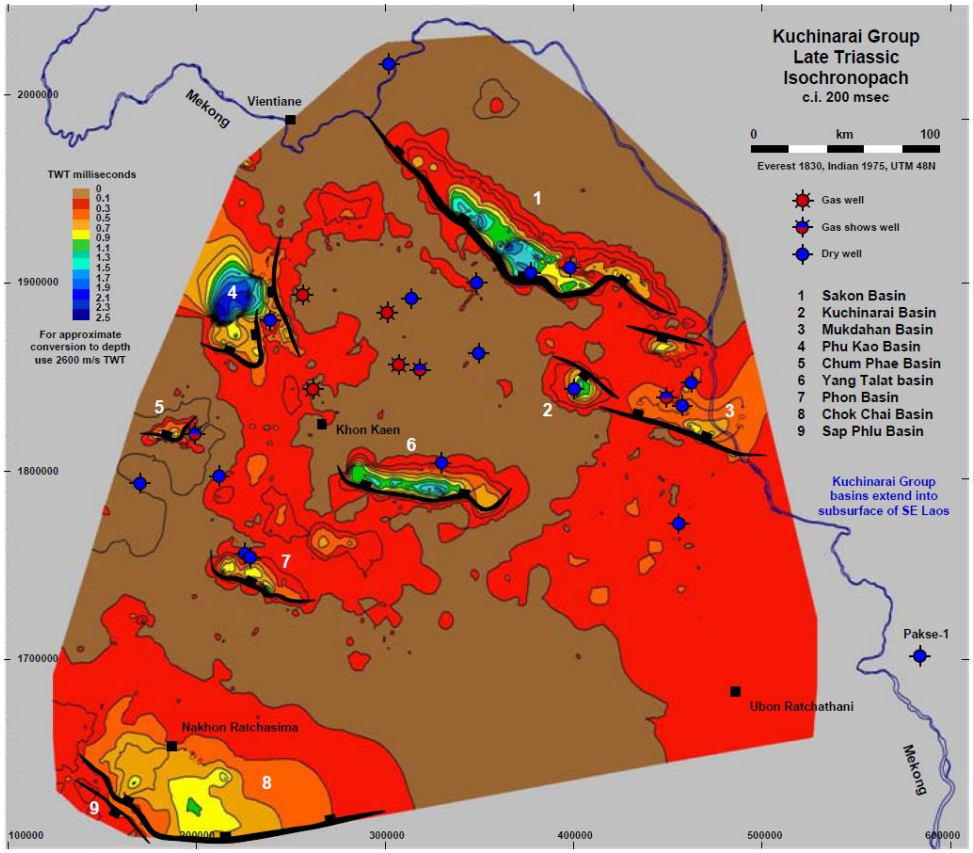




Transtensional Rift Basin

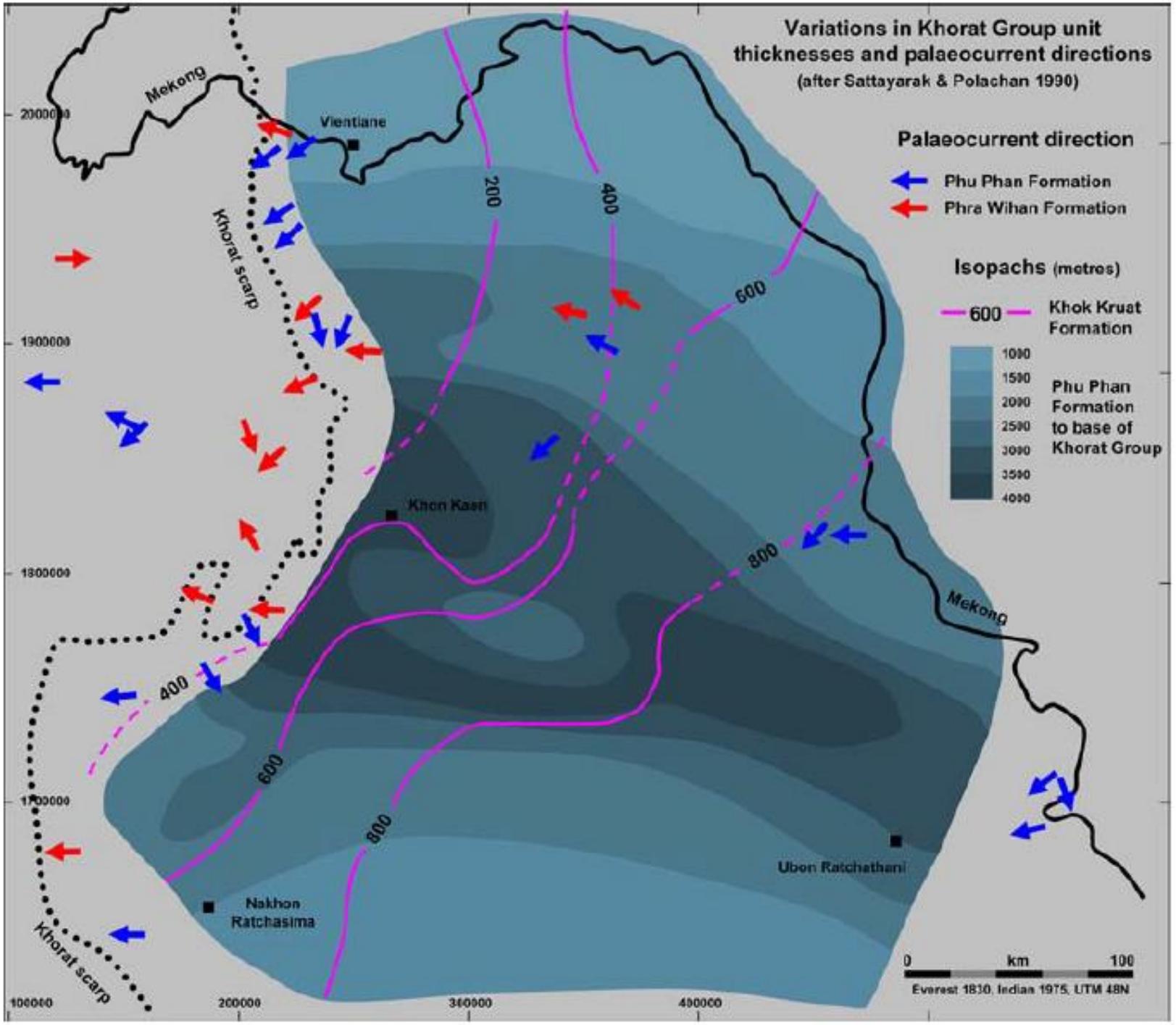


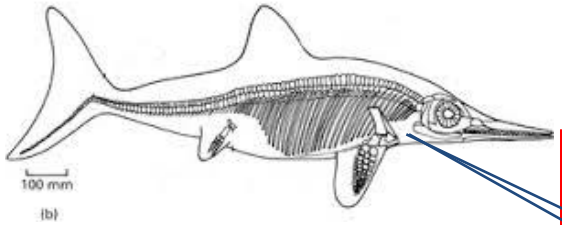


Cooper et al, 1989

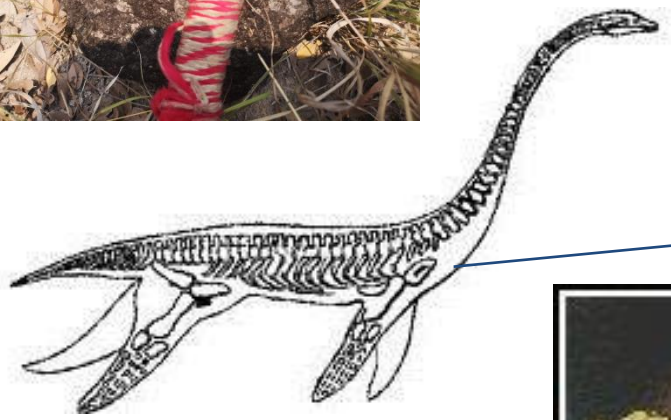
Booth and Sattayarak, 2011

Content


Variations in Khorat Group unit thicknesses and palaeocurrent directions
(after Sattayarak & Polachan 1990)
Palaeocurrent direction
Phu Phan Formation
Phra Wihan Formation
Isopachs (metres)
600
Khok Kruat Formation
1000
1500
2000
2500
3000
3500
4000
Phu Phan Formation to base of Khorat Group
Mekong
Vientiane
Khorat scarp
Khon Kaen
Ubon Ratchathani
Nakhon Ratchasima
200
400
600
800
0
km
100
Everest 1830, Indian 1975, UTM 48N



Ward & Bunnak, 1964



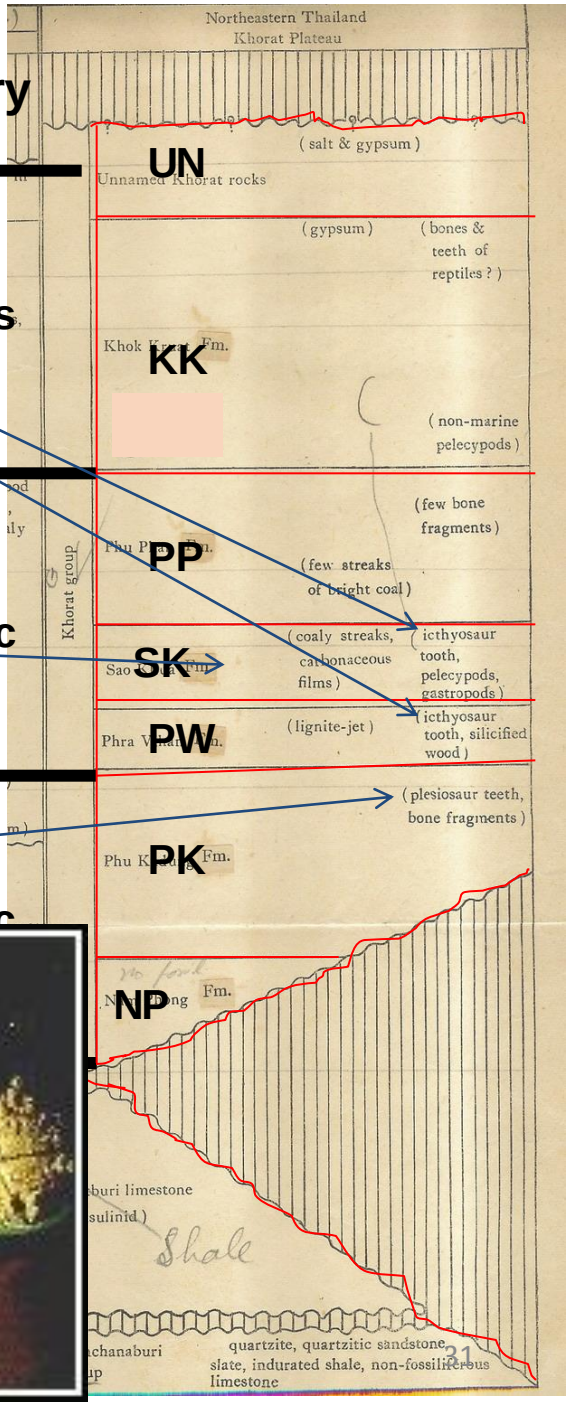
Khorat Group

Tertiary

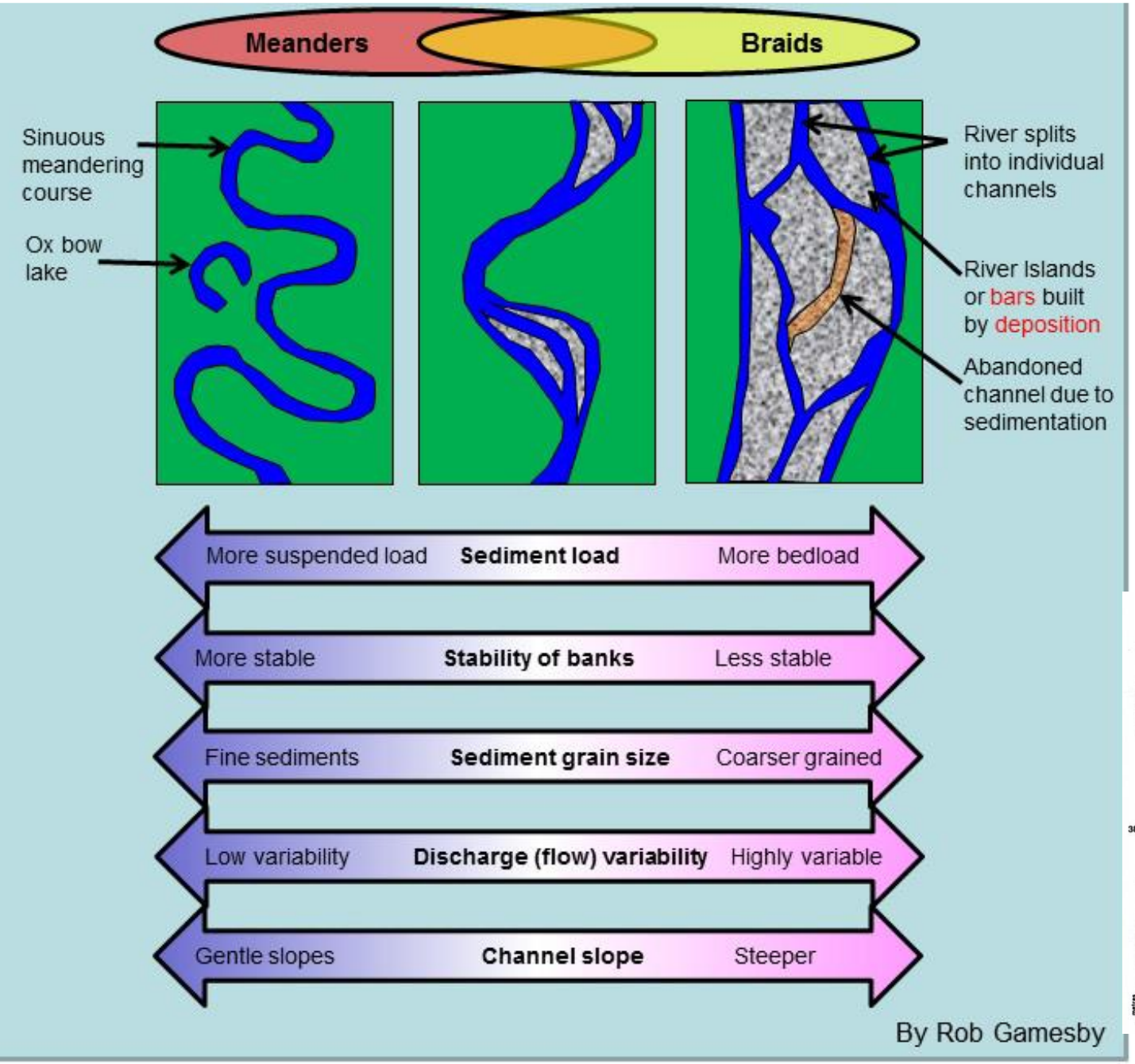
Cretaceous

Jurassic

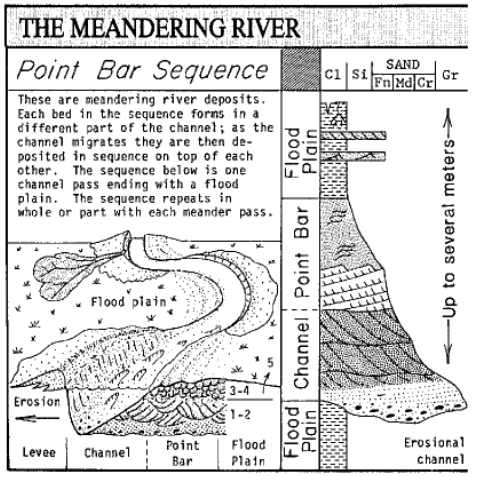
Triassic



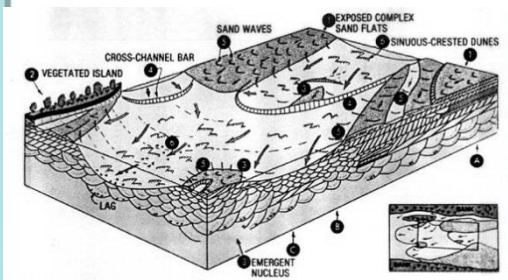
Meandering vs Braided River

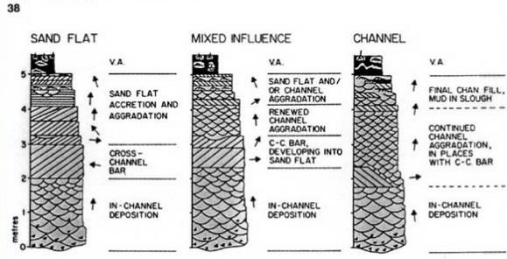


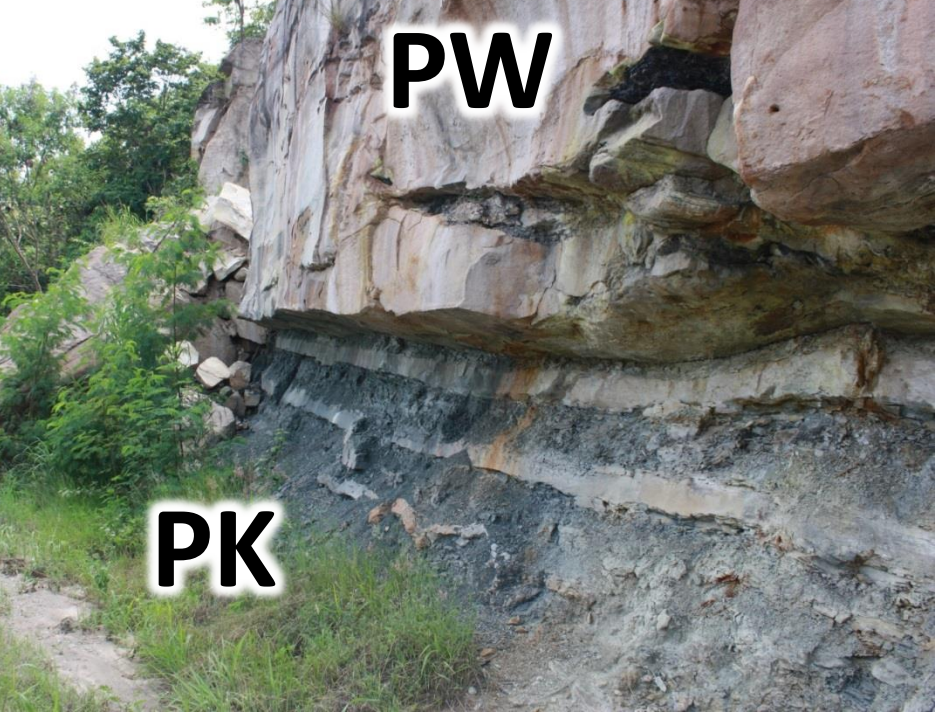
Meandering River



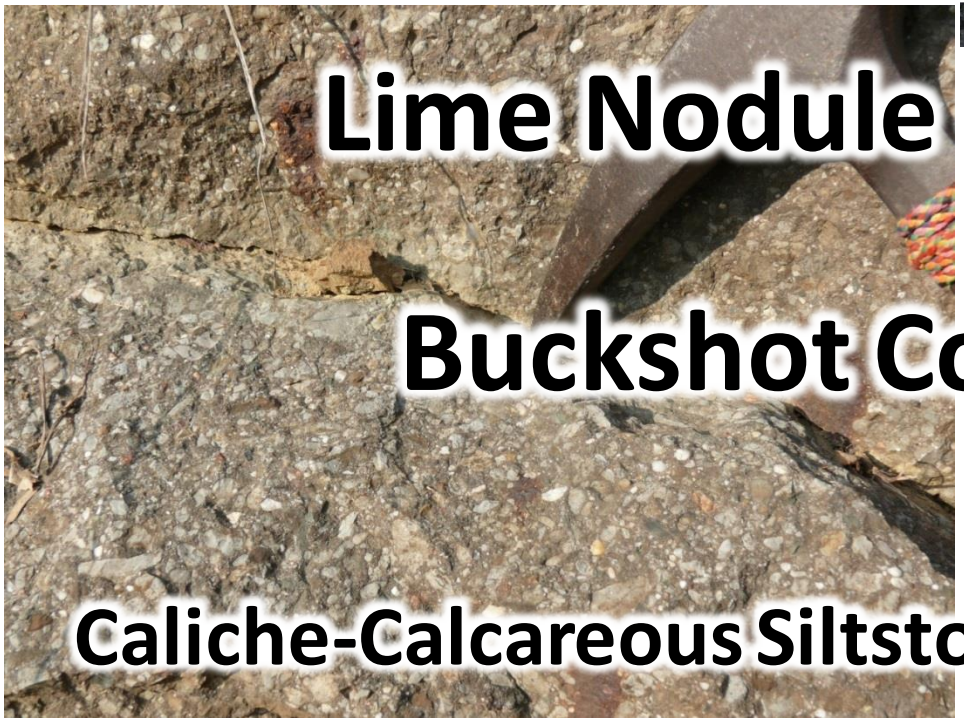
Braided River

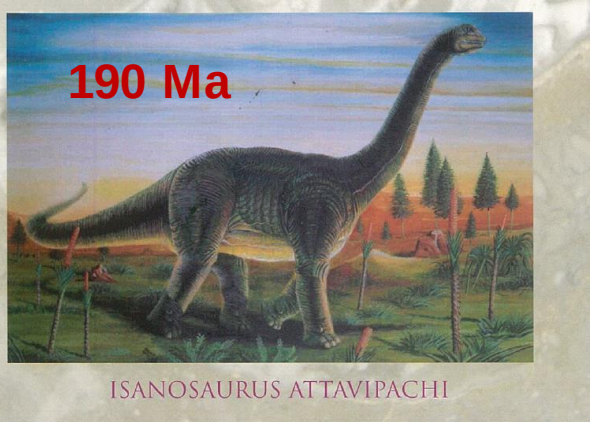




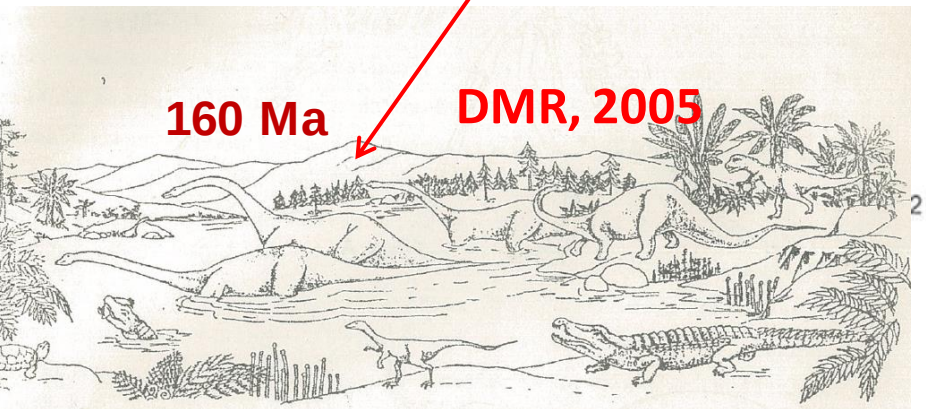

PW
PK

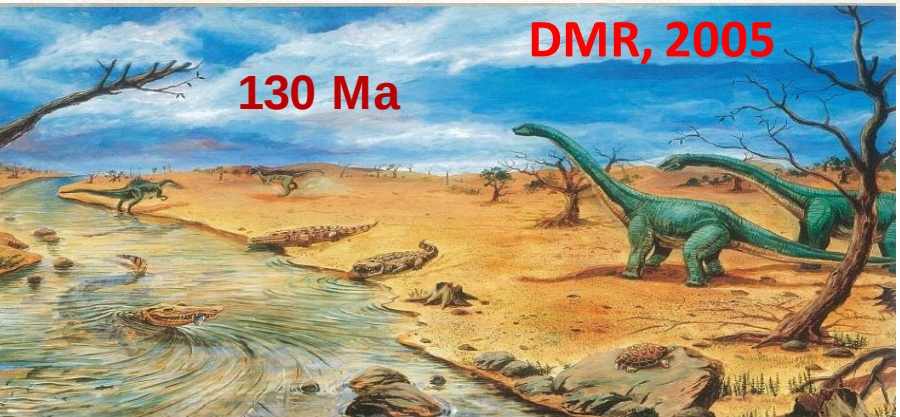

PP
SK

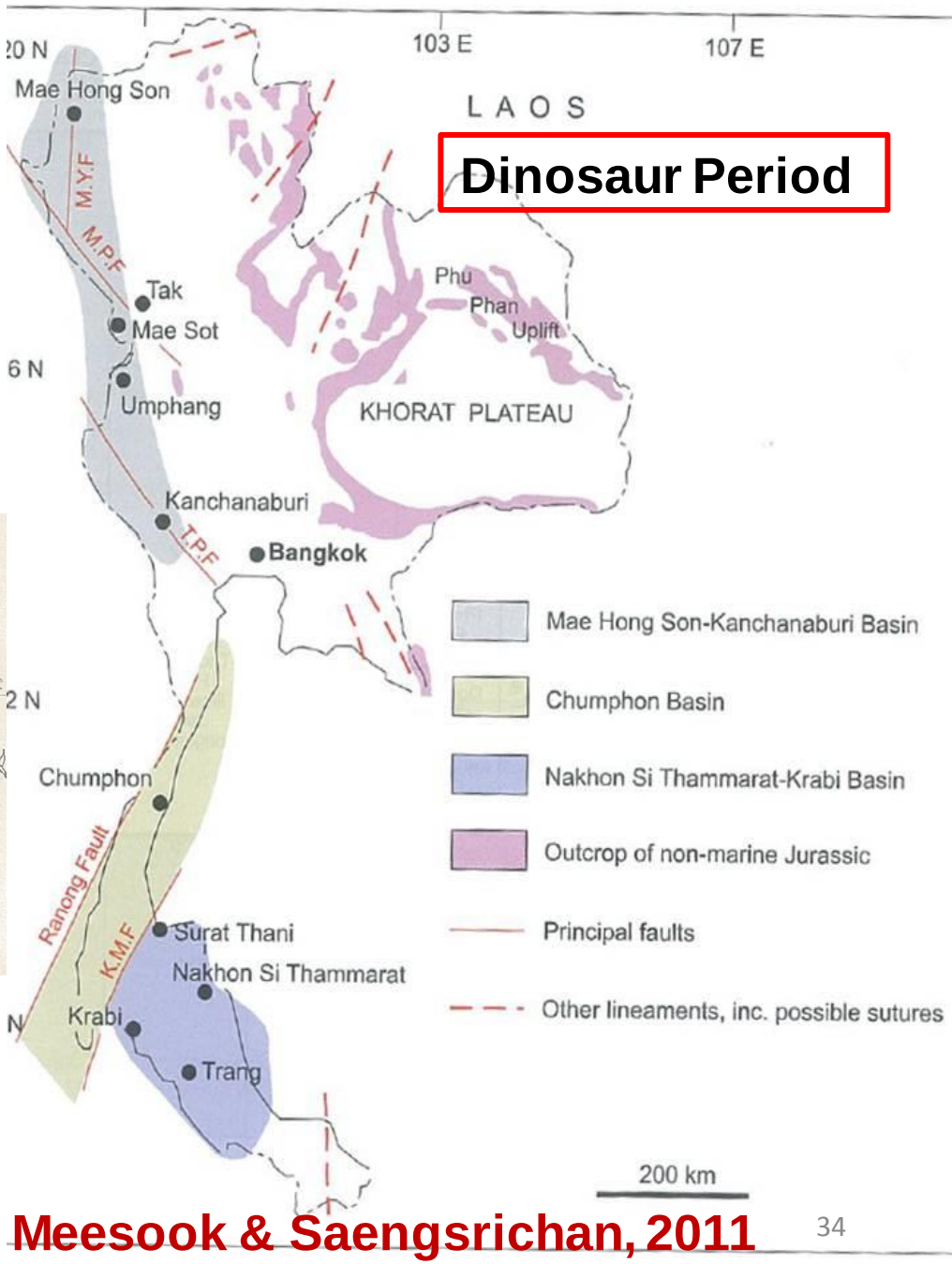

Lime Nodule Conglomerate
Buckshot Conglomerate
Caliche-Calcareous Siltstone Pebble Conglomerate



?



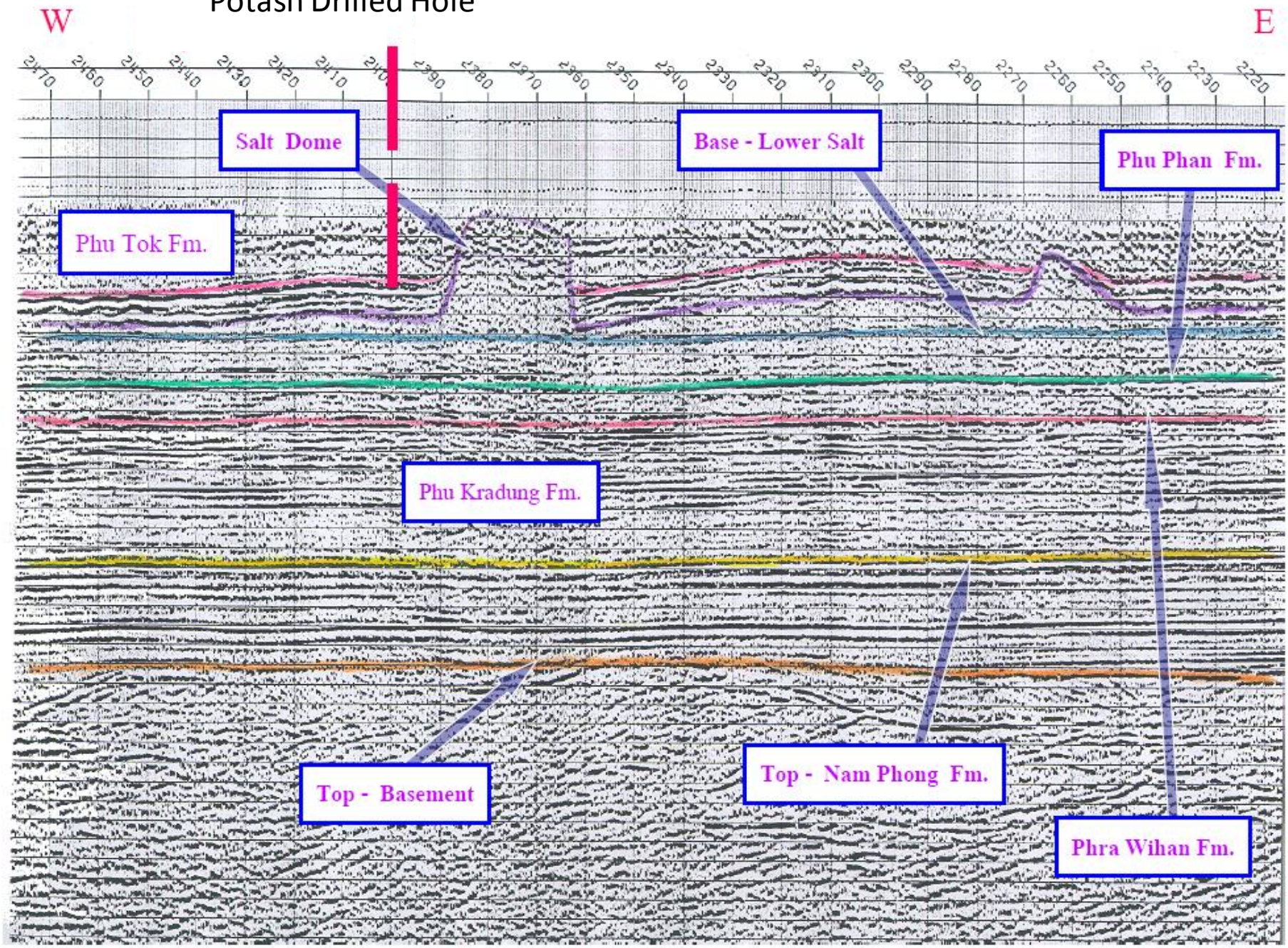


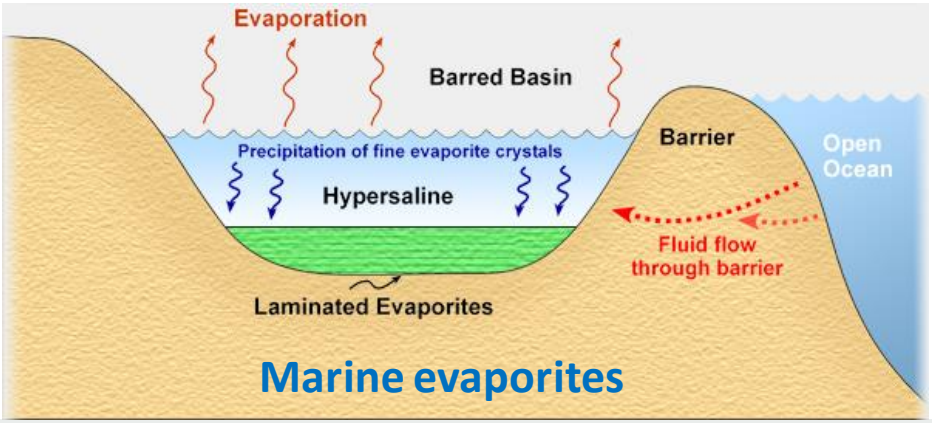


Meesook & Saengsrichan, 2011

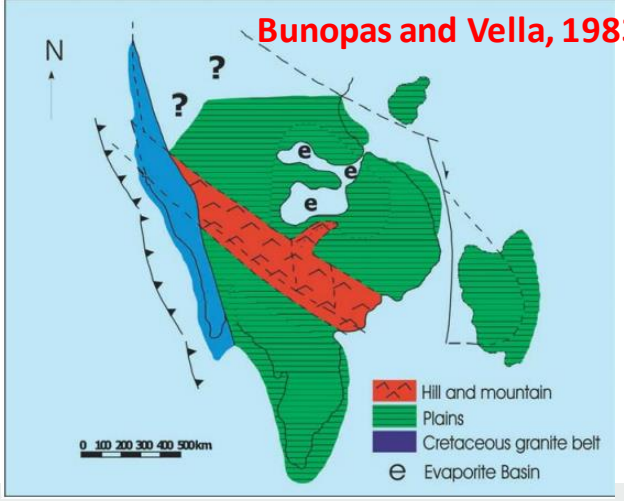
Content

Sattayarak and Polachan, 1990





Marine evaporites



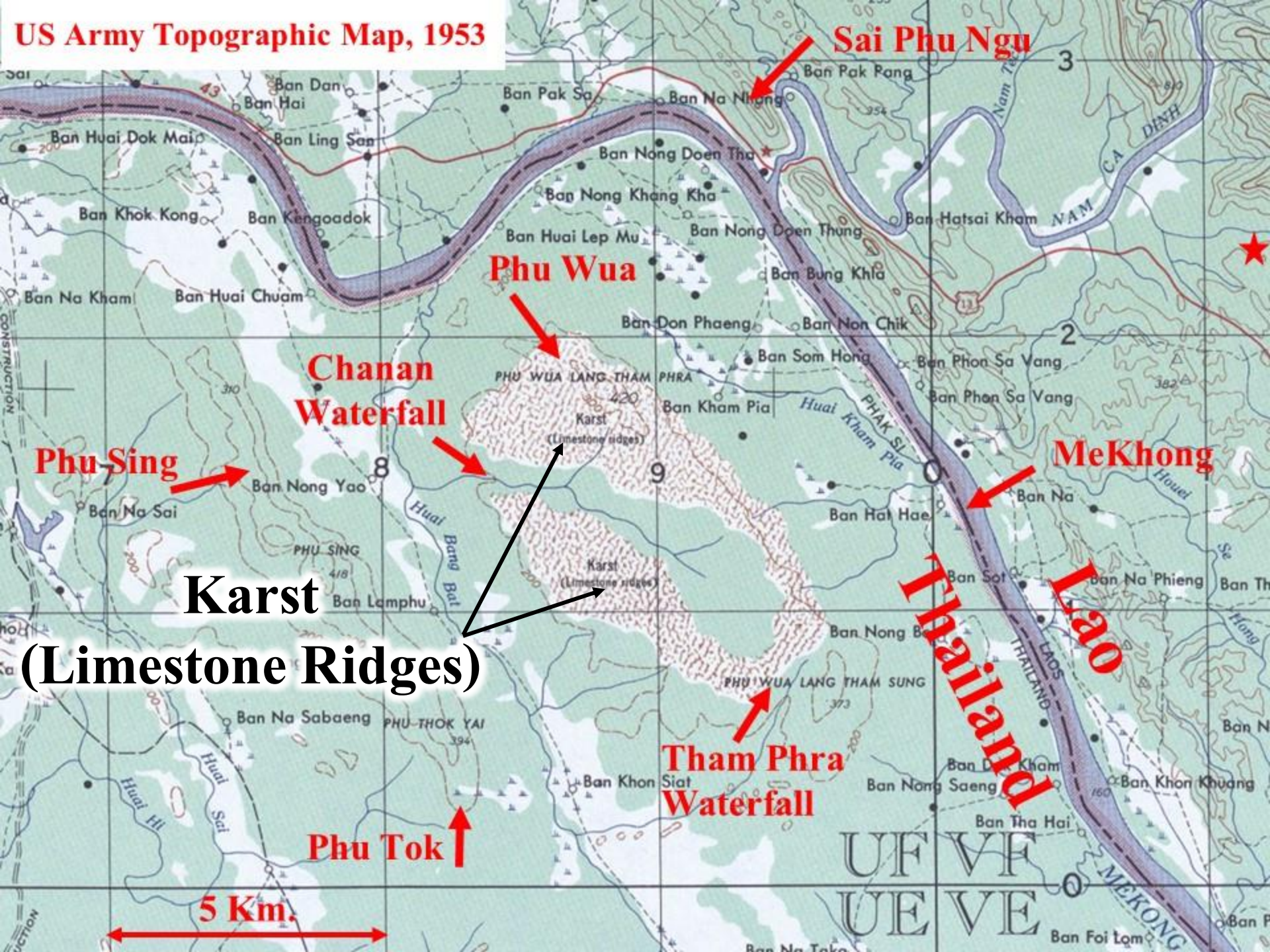
Bunopas and Vella, 1983

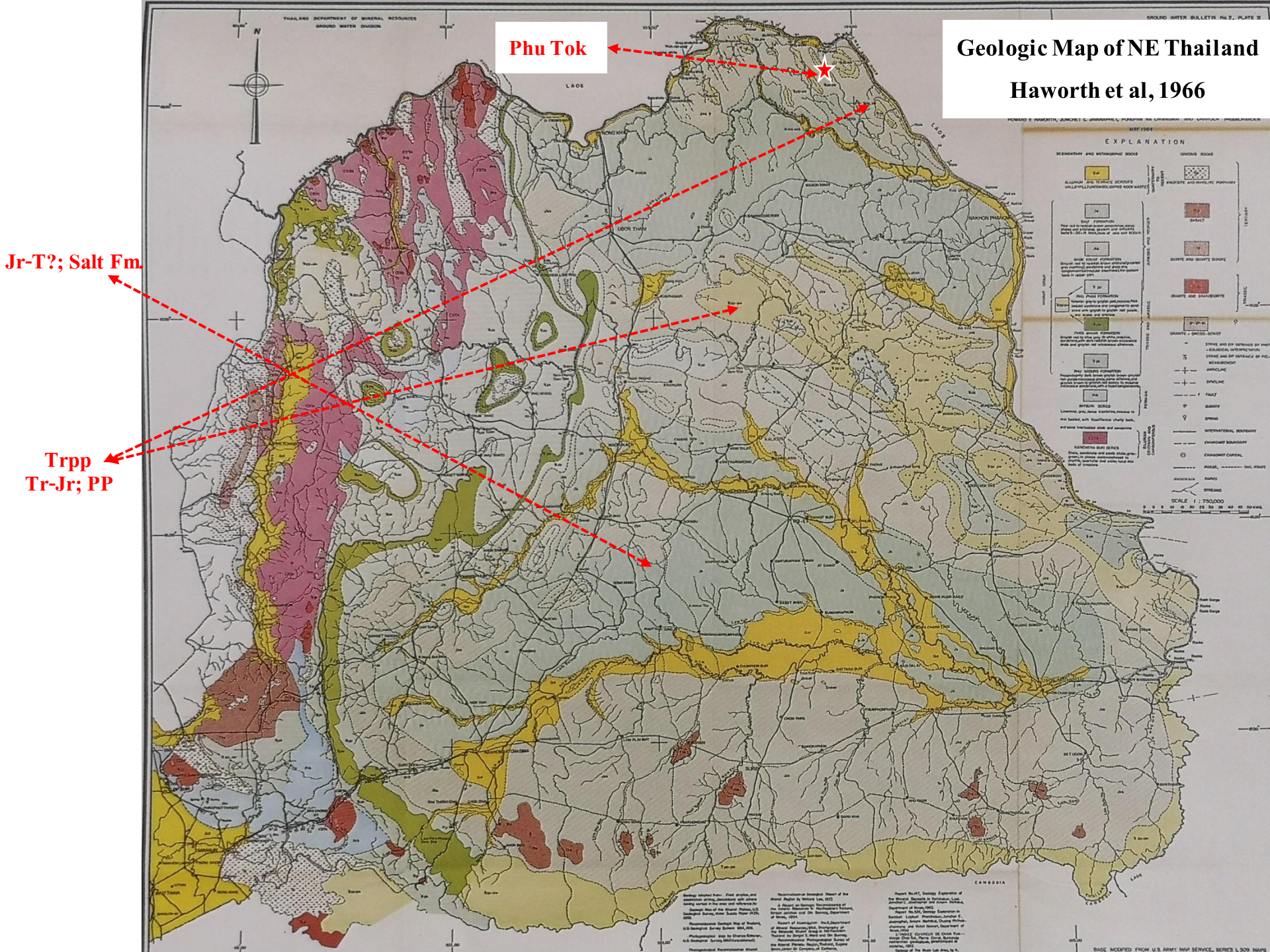
List of Reviews	Sample	Methodology	Study area	Conclusion
Hite and Japakasetr (1979)	Drillholes	Br concentration	SKB and KB	Marine origin
Yumuang et al. (1986)	Drillholes	Lithology and Stratigraphy	SKB and KB	
El Tabakh et al. (1999)	Anhydrite	S isotope	SKB and KB	
	Halite	Br concentration	SKB and KB	
Timofeeff et al. (2006)	Halite	Geochemical analysis	SKB	
Tan et al. (2010)	Halite and Potash	B and Sr isotopes	SKB	
Zhang et al. (2013)	Borate minerals	B isotope	SKB	
Ren et al. (2018)	Halite	B isotope	SKB	
Qin et al. (2020)	Gypsum, Anhydrite and Halite	B, Sr and S isotopes	SKB and KB	
Utha-aroon (1993)	Drillholes	Sedimentology and Mineralogy	SKB and KB	Non-marine origin
Ren et al. (2018)	Carnallite and Sylvite	B and Br concentrations	SKB	
Sun et al (2019)	Halite	Cl and Br concentrations	SKB	
El Tabakh et al. (1999)	Tachyhydrite and Borate minerals	Mineralogy	SKB and KB	Mixed fluid origin such as Hydrothermal, Meteoric water
Li et al. (2018)	Halite	Sr isotope	SKB	
Ren et al. (2018)	Carnallite	B concentration	SKB	
Li et al. (2020)	Halite and Potash minerals	Cl and Br concentrations and Cl isotope	KB	
Sattayarak (1991)	Kerogen of pollen	-	-	Middle Cretaceous (Albian - Cenomanian)
Hansen et al. (2002)	Claystone of the Middle Clastic Unit	Multiple isotopes	KB	
Hansen et al. (2016)	Anhydrites of the Middle Salt Unit	Sr isotope	KB	

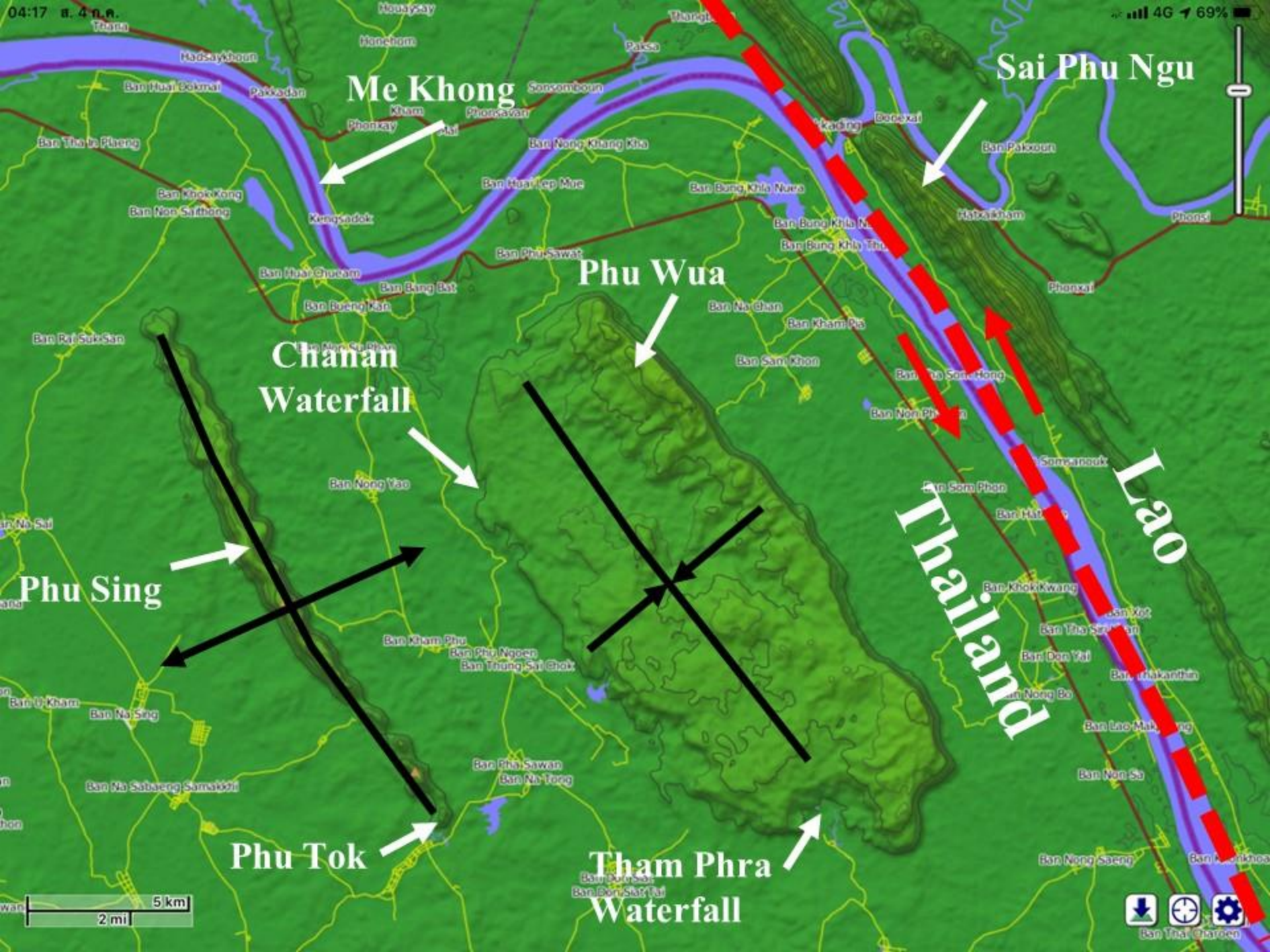
* **Note:** SKB = Sakon Nakhon Basin; KB = Khorat Basin; "-" = Unknow

Rattana et al, 2021

Content


US Army Topographic Map, 1953
Sai Phu Ngu
Phu Wua
Chanan Waterfall
Phu Sing
MeKhong
Karst (Limestone Ridges)
Lao
Thailand
Tham Phra Waterfall
Phu Tok
5 Km.
Ban Pak Pang
Ban Na Nhang
Ban Pak Sa
Ban Dan
Ban Hai
Ban Huai Dok Mai
Ban Ling San
Ban Nong Doen Tha
Ban Nong Khang Kha
Ban Khok Kong
Ban Kengoadok
Ban Huai Lep Mu
Ban Nong Doen Thung
Ban Hatsai Kham
Ban Na Kham
Ban Huai Chuam
Ban Bung Khla
Ban Don Phaeng
Ban Non Chik
Ban Som Hong
Ban Phon Sa Vang
PHU WUA LANG THAM PHRA
Ban Kham Pia
Huai Kham Pia
Ban Na Sai
Ban Nong Yao
Huai Bang Bat
PHU SING
Ban Lamphu
Ban Hat Hae
Ban Na
Ban Sot
Ban Na Phieng
PHU WUA LANG THAM SUNG
Ban Na Sabaeng
PHU THOK YAI
Huai Hi
Huai Sai
Ban Khon Siat
Ban Nong Saeng
Ban Khon Khuang
Ban Tha Hai
Ban Foi Lom
Nam Te
Nam Ca Dinh
Houei
Se
Hong
LAOS
THAILAND
MEKONG


Phu Tok
Geologic Map of NE Thailand
Haworth et al, 1966
Jr-T?; Salt Fm.
Trpp
Tr-Jr; PP
EXPLANATION
LAOS
CAMBODIA
THAILAND DEPARTMENT OF MINERAL RESOURCES
GROUND WATER DIVISION


Me Khong
Sai Phu Ngu
Phu Wua
Chanan
Waterfall
Phu Sing
Phu Tok
Tham Phra
Waterfall
Thailand
Lao
5 km
2 mi

ลานอเมริกา ภูวัว บึงกาฬ

น้ำตกชะแนน ภูวัว บึงกาฬ

หลังถ้ำพราย ภูวัว บึงกาฬ

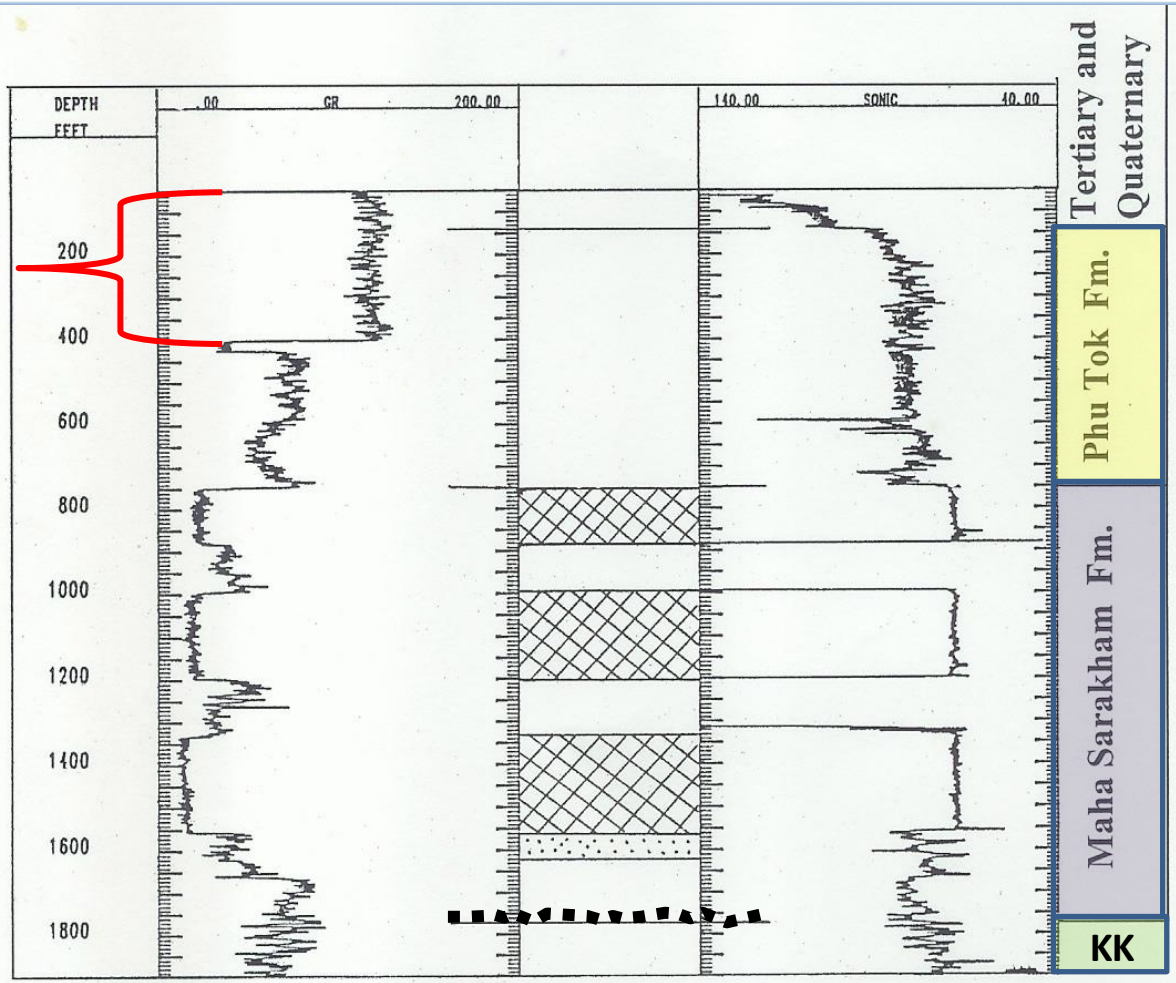
Tham Phra Waterfall, Bung Kan

น้ำจืดกับคราบเกลือ

บ่อพันขัน
ทุ่งกุลาร้องไห้
ปัจจุบัน

บ่อพันขัน
พ.ศ. 2509

Cased Hole



Yang Talat 1X
Ms & PT
Stratigraphy

หมวดหินภูทอก

กรมทรัพยากรธรณีแบ่งออกเป็น

. หมู่หินภูทอกน้อย(249 ม.)

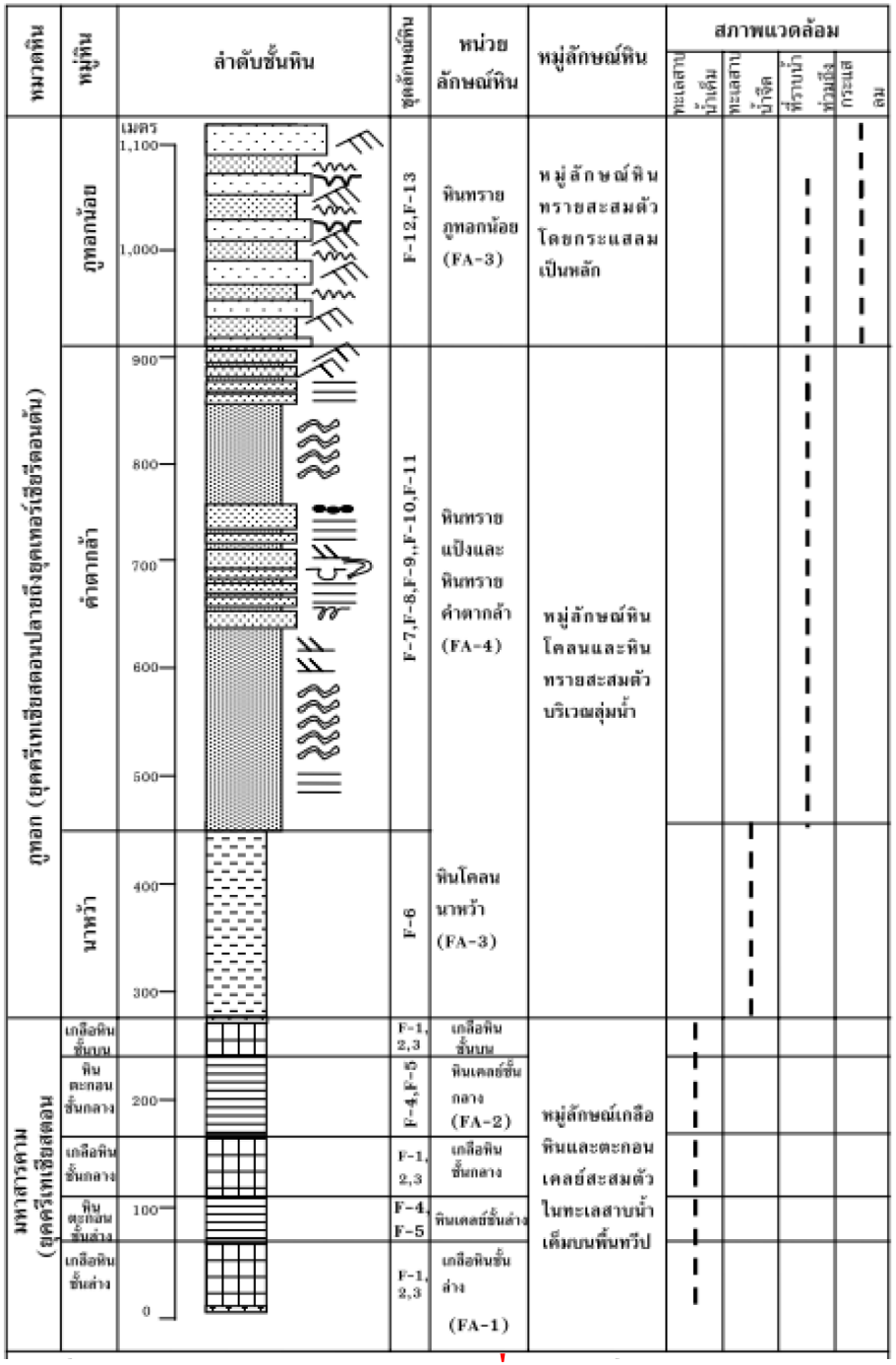
ส่วนใหญ่เป็นหินทราย

. หมู่หินคำตากล้า(475 ม.)

หินทรายแป้งกับหินทราย

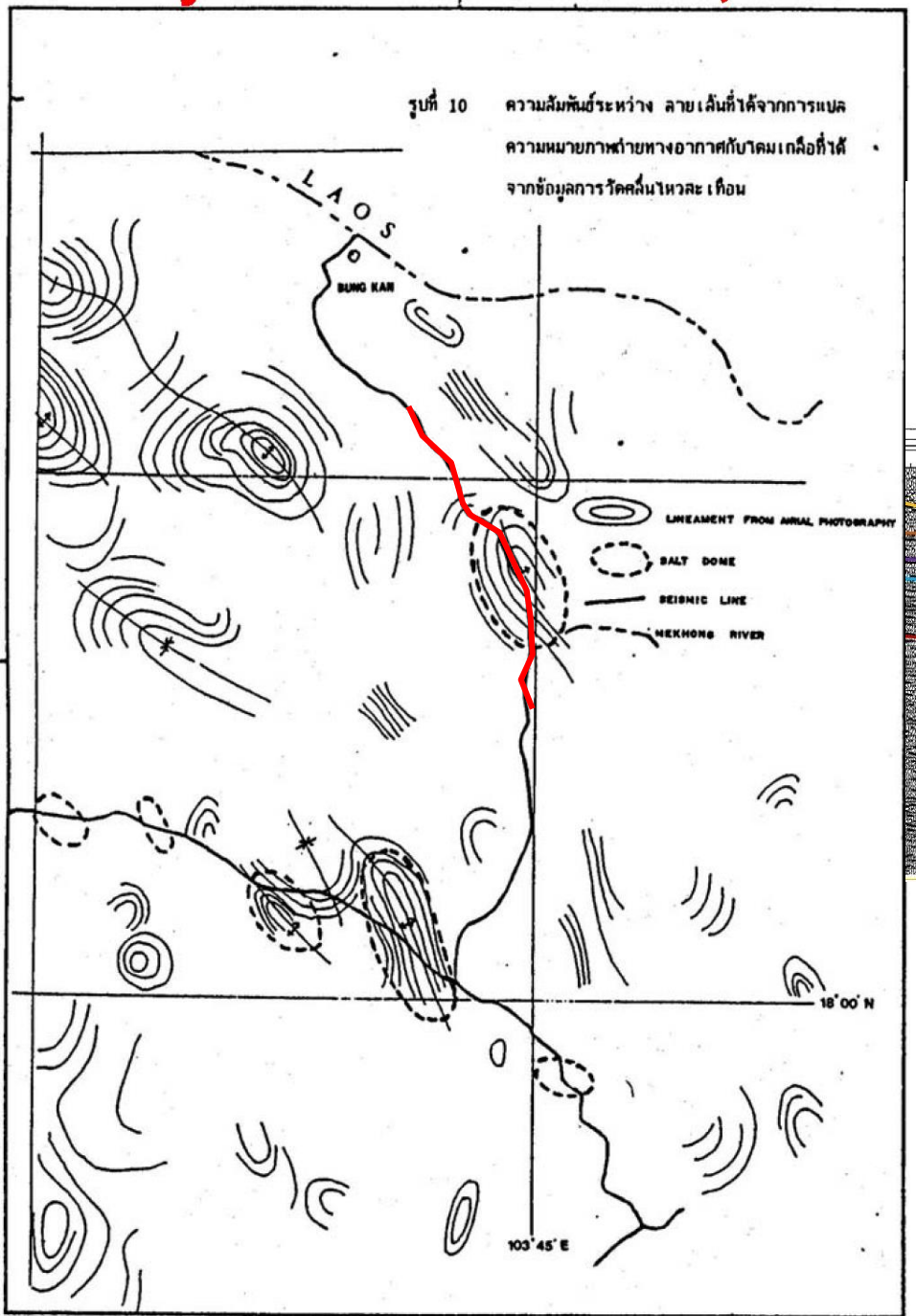
. หมู่หินนาหว้า (15-230 ม.)

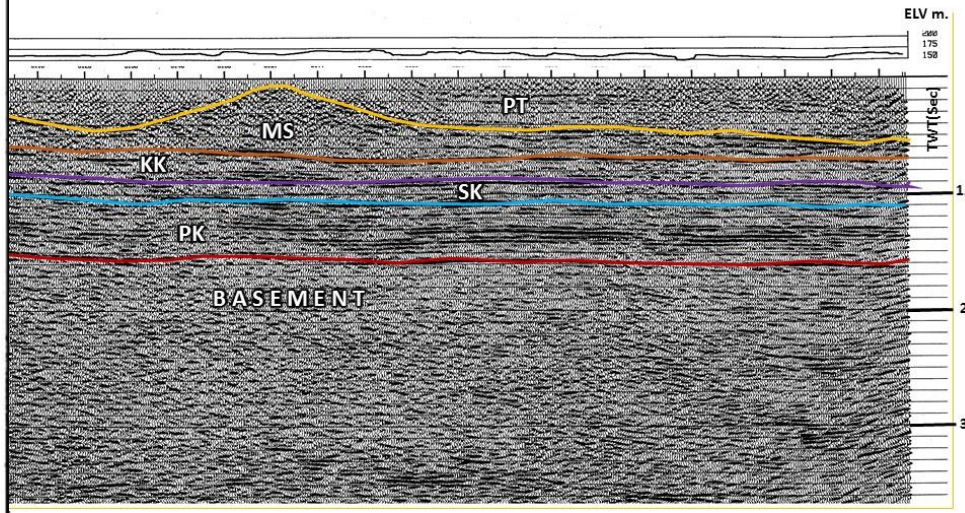
หินโคลน

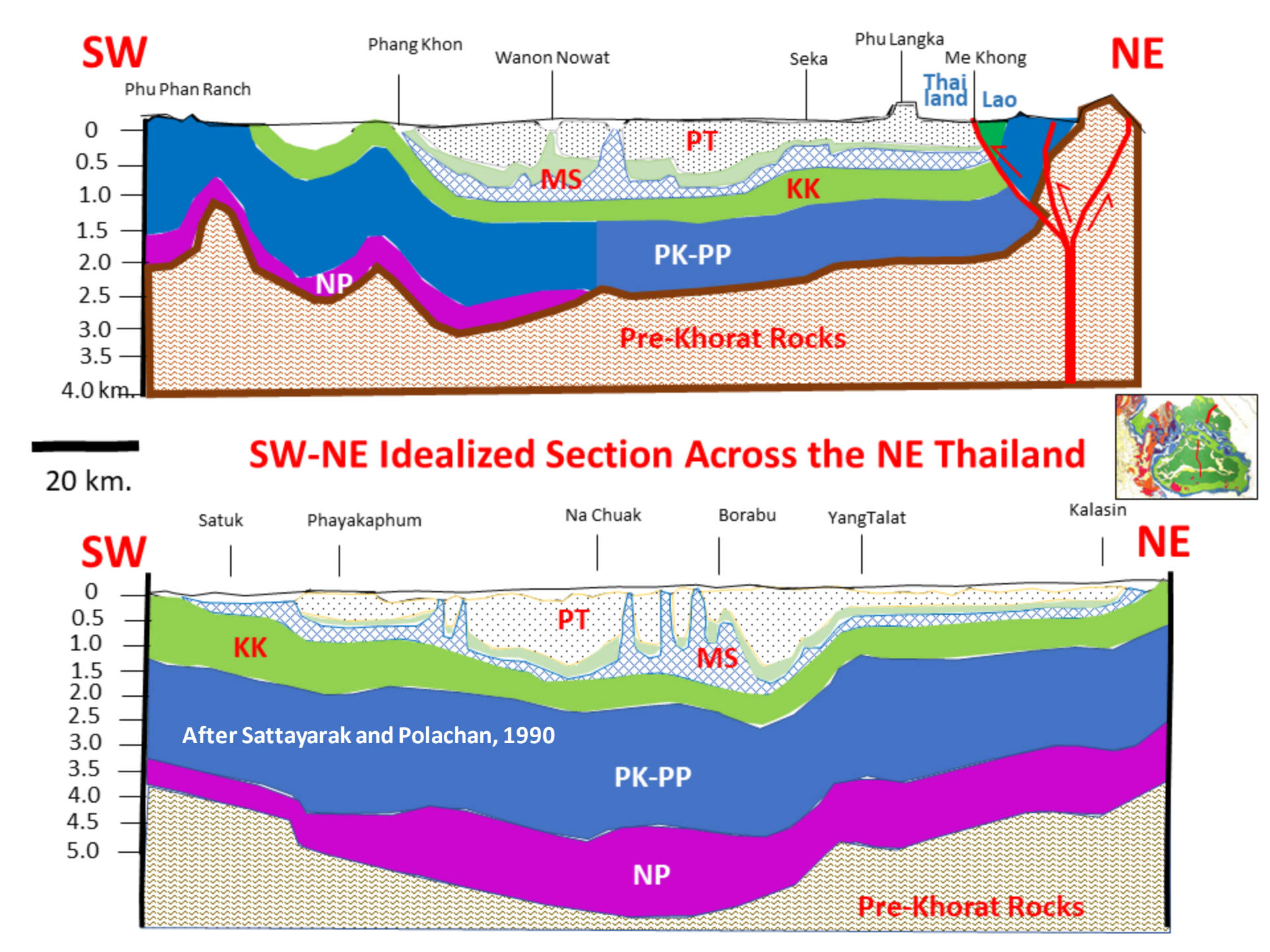


เด่นโชค มั่นใจ (2549)

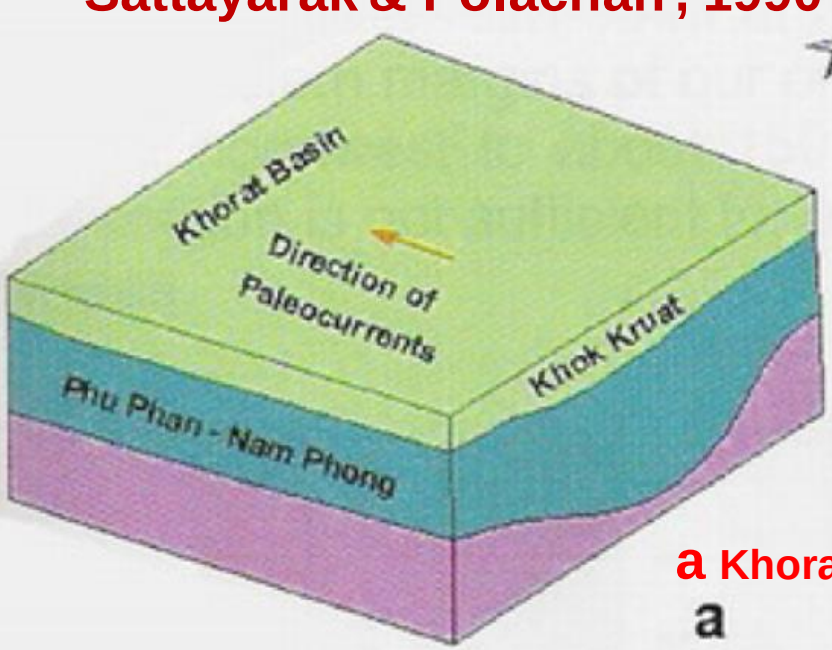
Sattayarak & Polachan, 1990






SW
NE
Phu Phan Ranch
Phang Khon
Wanon Nowat
Seka
Phu Langka
Me Khong
Thai land
Lao
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0 km.
PT
MS
KK
PK-PP
NP
Pre-Khorat Rocks
20 km.
SW-NE Idealized Section Across the NE Thailand
Satuk
Phayakaphum
Na Chuak
Borabu
YangTalat
Kalasin
SW
NE
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
KK
PT
MS
After Sattayarak and Polachan, 1990
PK-PP
NP
Pre-Khorat Rocks

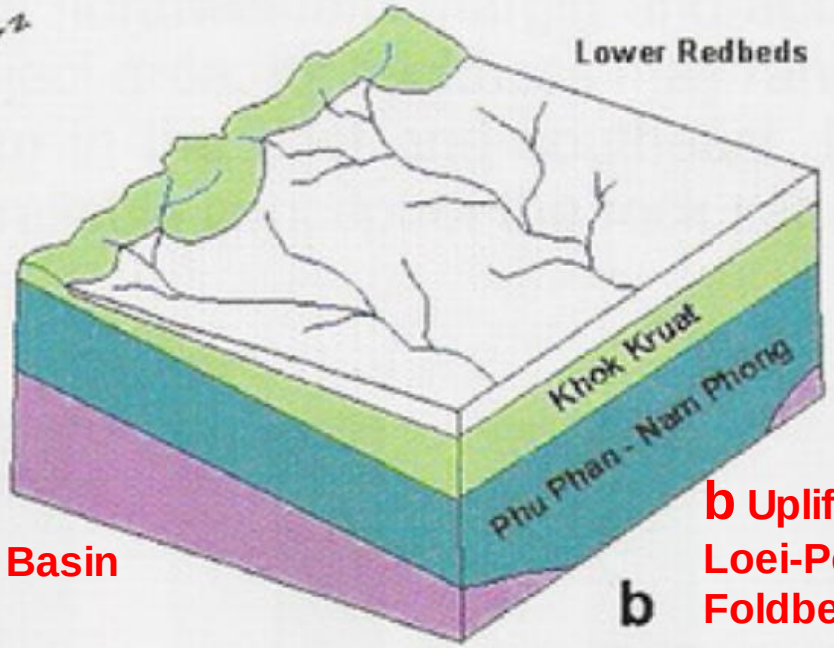
Sattayarak & Polachan , 1990



a Khorat Basin

a

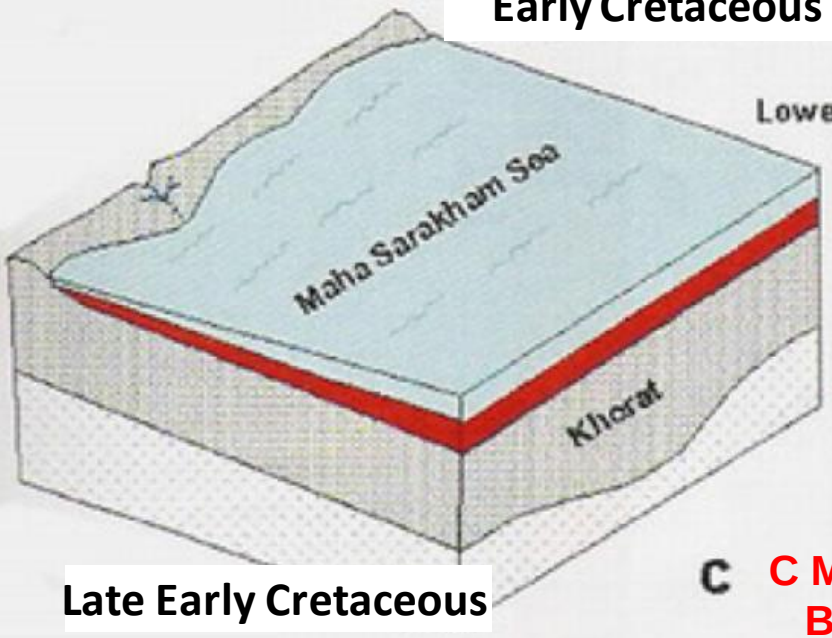
Early Cretaceous



b Uplifting of Loei-Petchabun Foldbelt

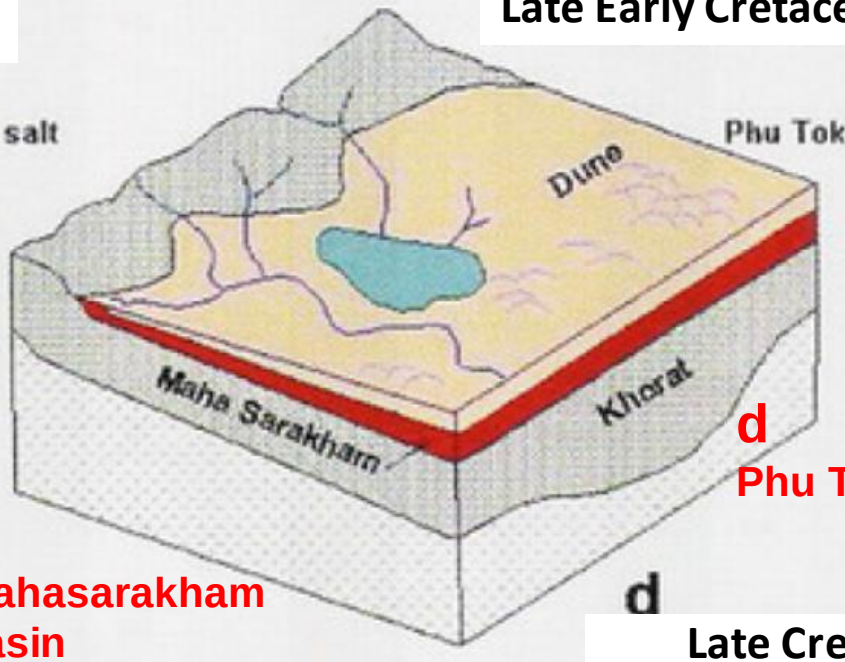
b

Late Early Cretaceous



Late Early Cretaceous

c C Mahasarakham Basin

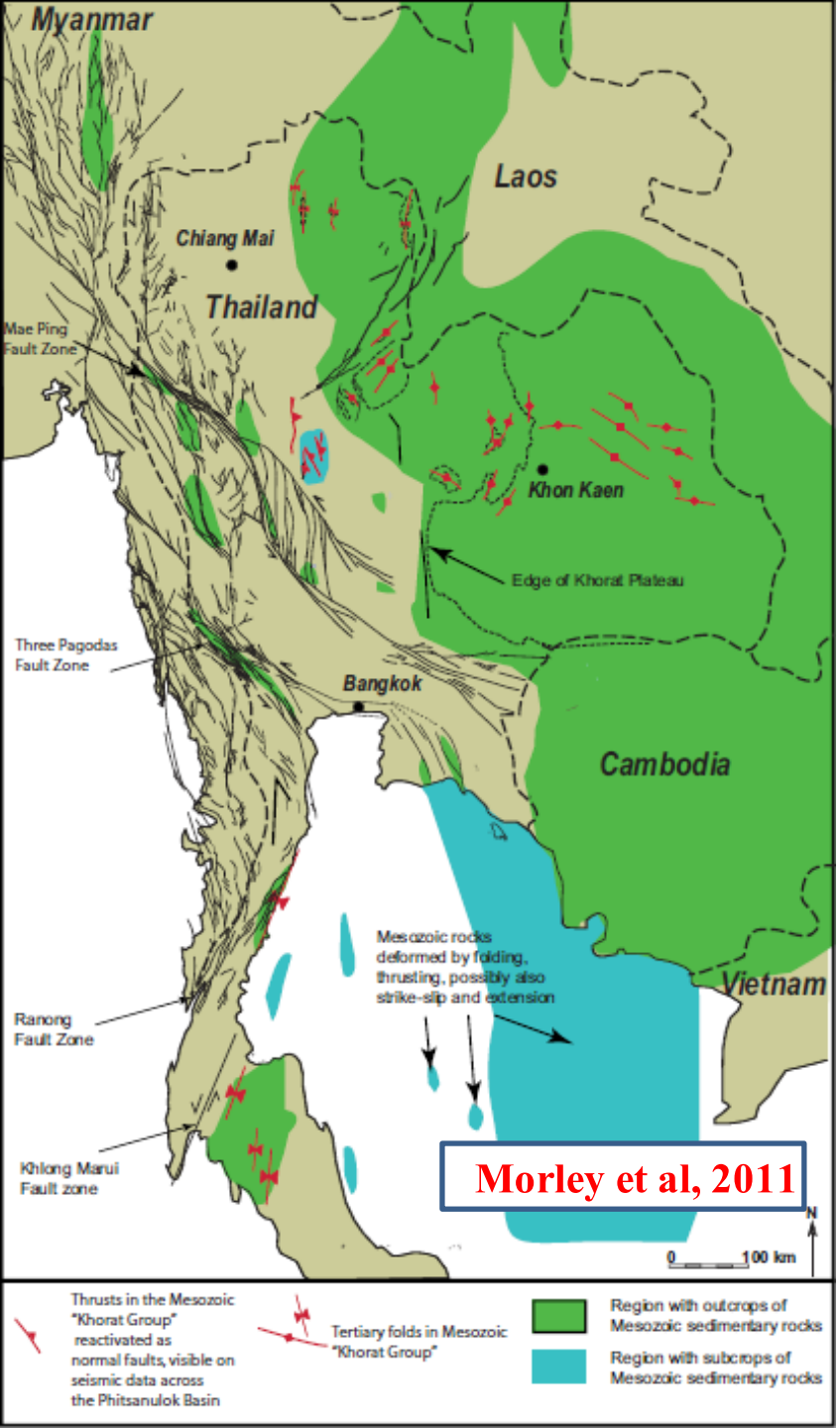


d Phu Tok Basin

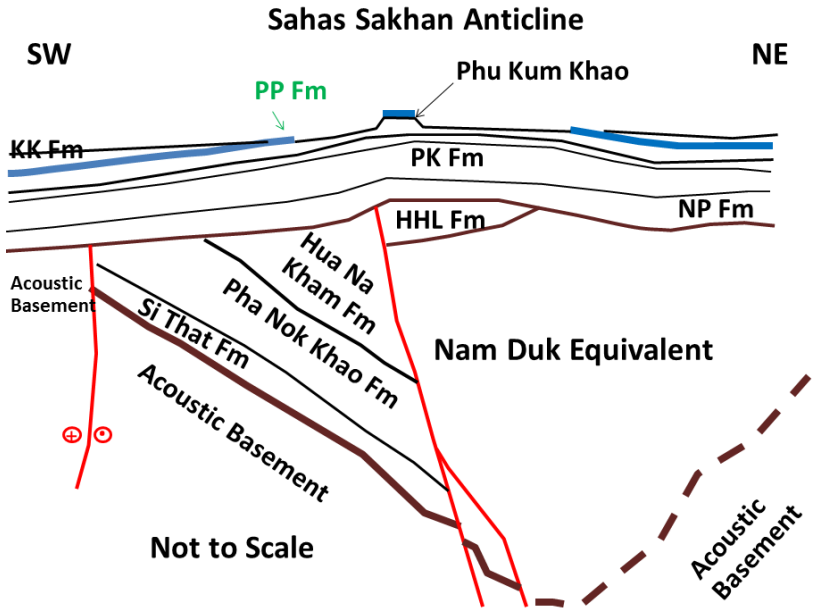
d

Late Cretaceous

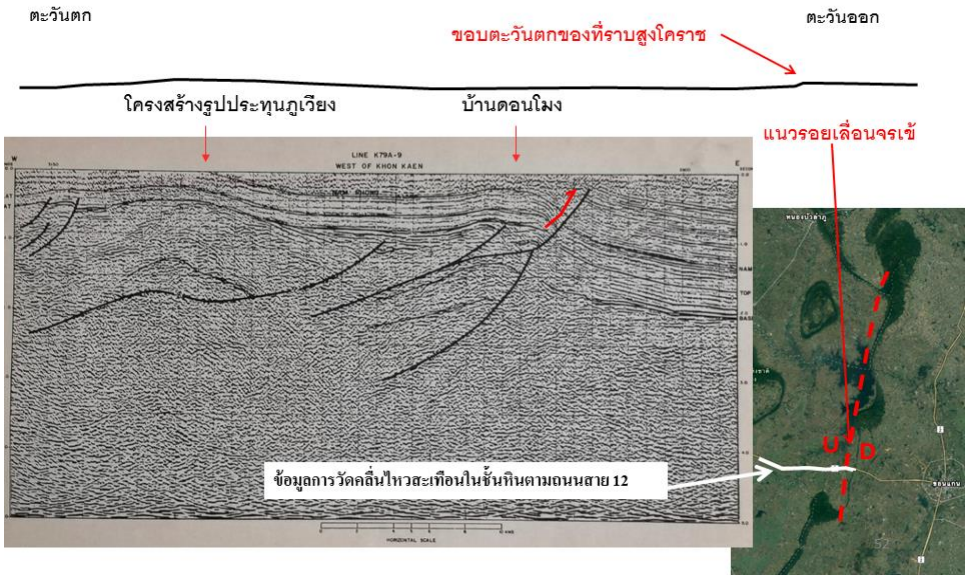
Content



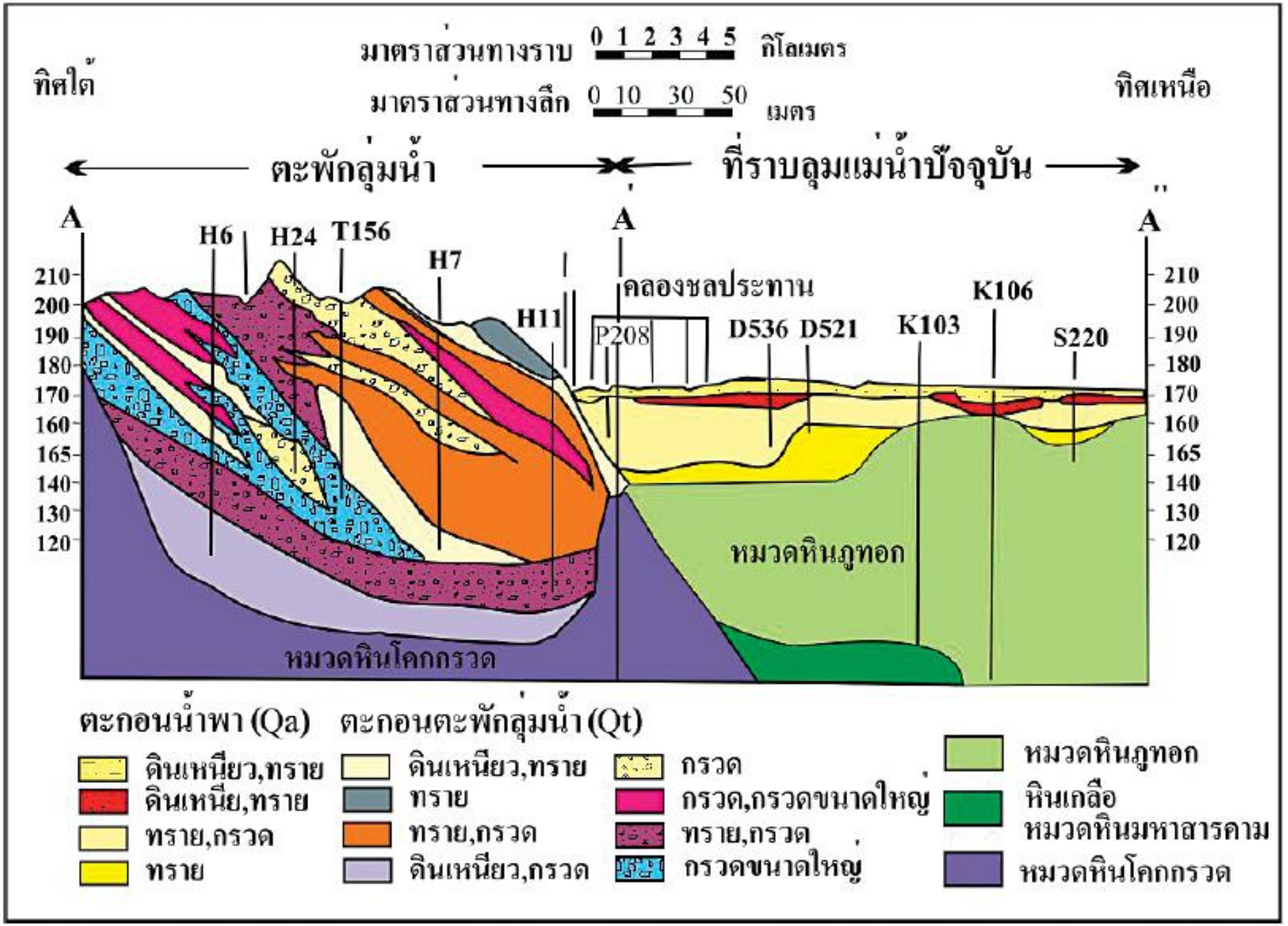
โครงสร้างรูปประทุนสหัสขันธ์เกิดจากการเคลื่อนย้อนกลับของรอยเลื่อนที่ทำให้เกิดแอ่งสหัสขันธ์



ขอบที่ราบสูงโคราชในบริเวณนี้เกิดจากแนวเลื่อนย้อนกลับจรเข้



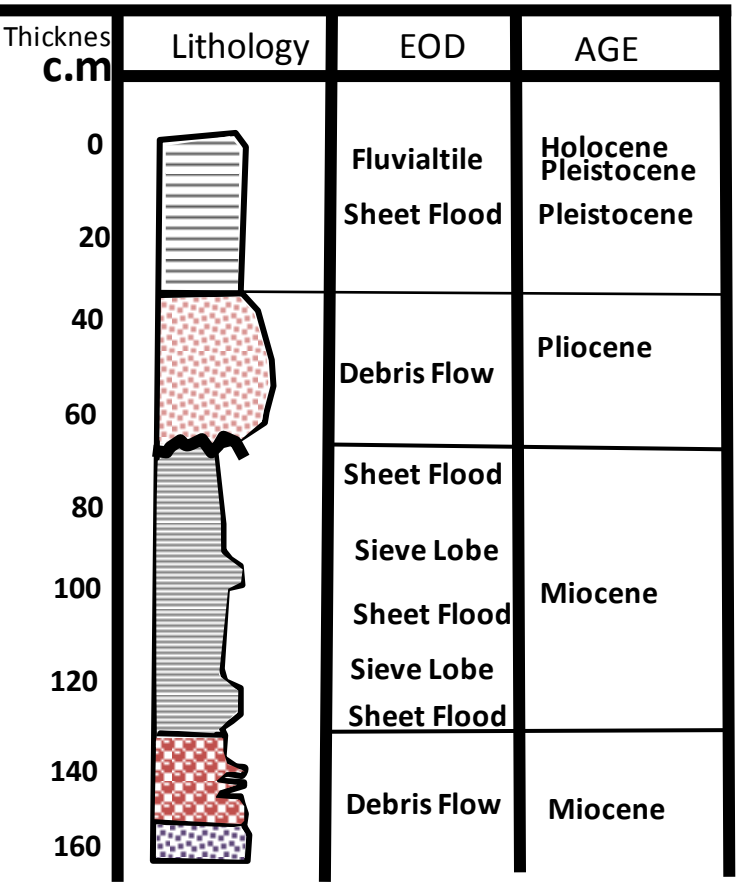
Content



Wongsawat et al, 1992

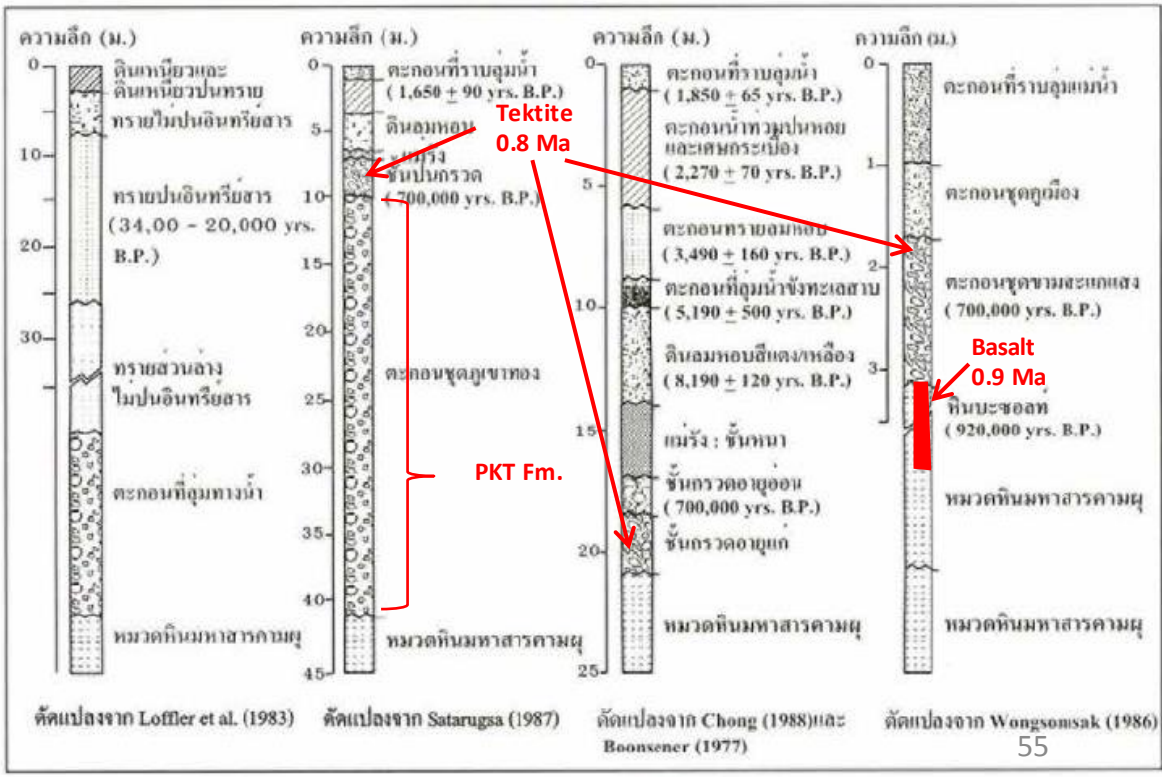
Stratigraphic Columnn Nong Bua Ri Sand Pit, Nakornratchasima

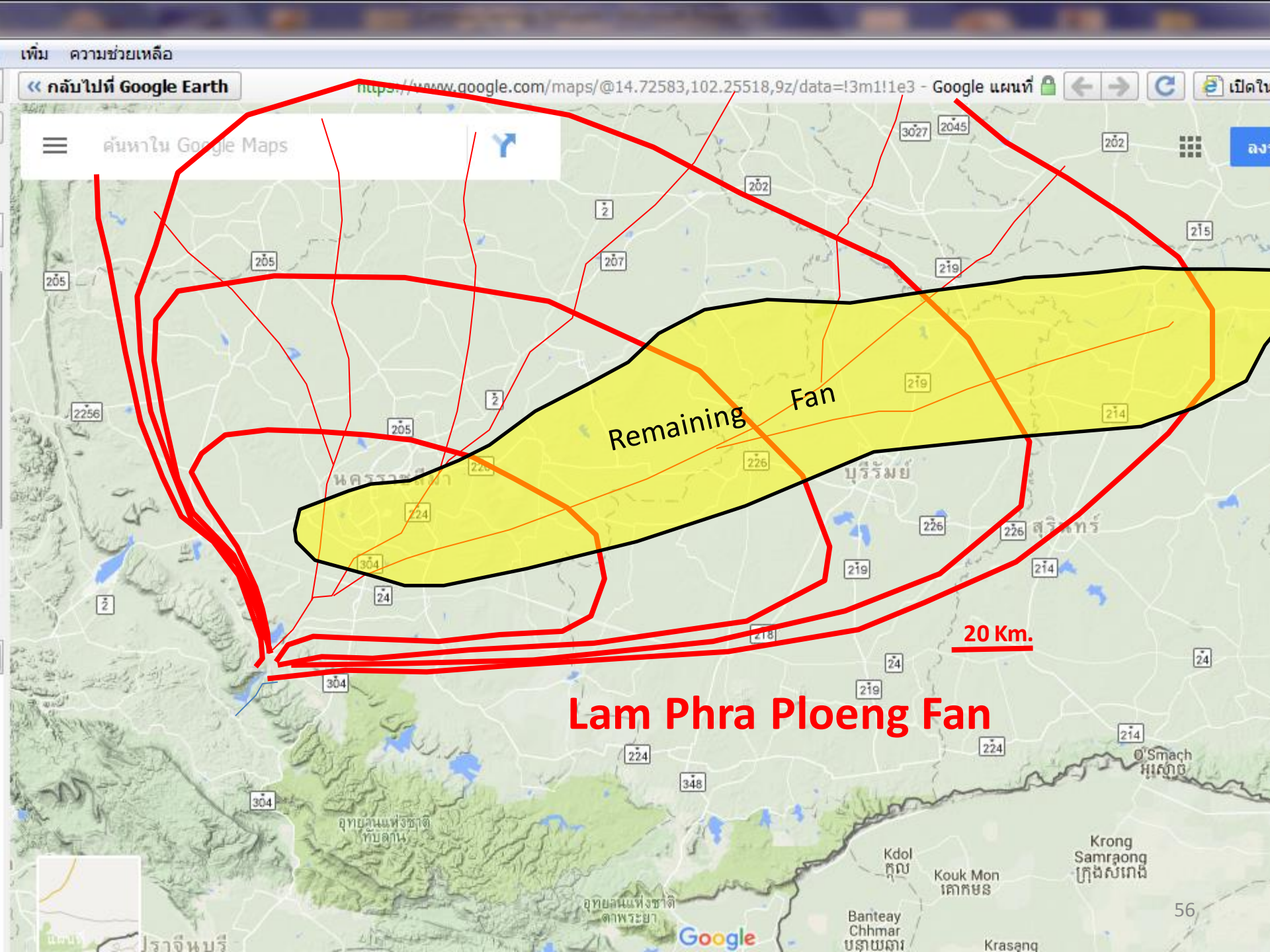
Nakchaiya, 2002



Young Sediments on top of Khorat Plateau

Nutalaya, 1989




Remaining Fan
20 Km.
Lam Phra Ploeng Fan

Content

ISAN Geology Yield Us

- Mineral & Mining Business
- Rock salt & Potash Industries
- Petroleum Fields
- Groundwater Enrichment
- Salty Soil
- Geotourism
- Geohazard

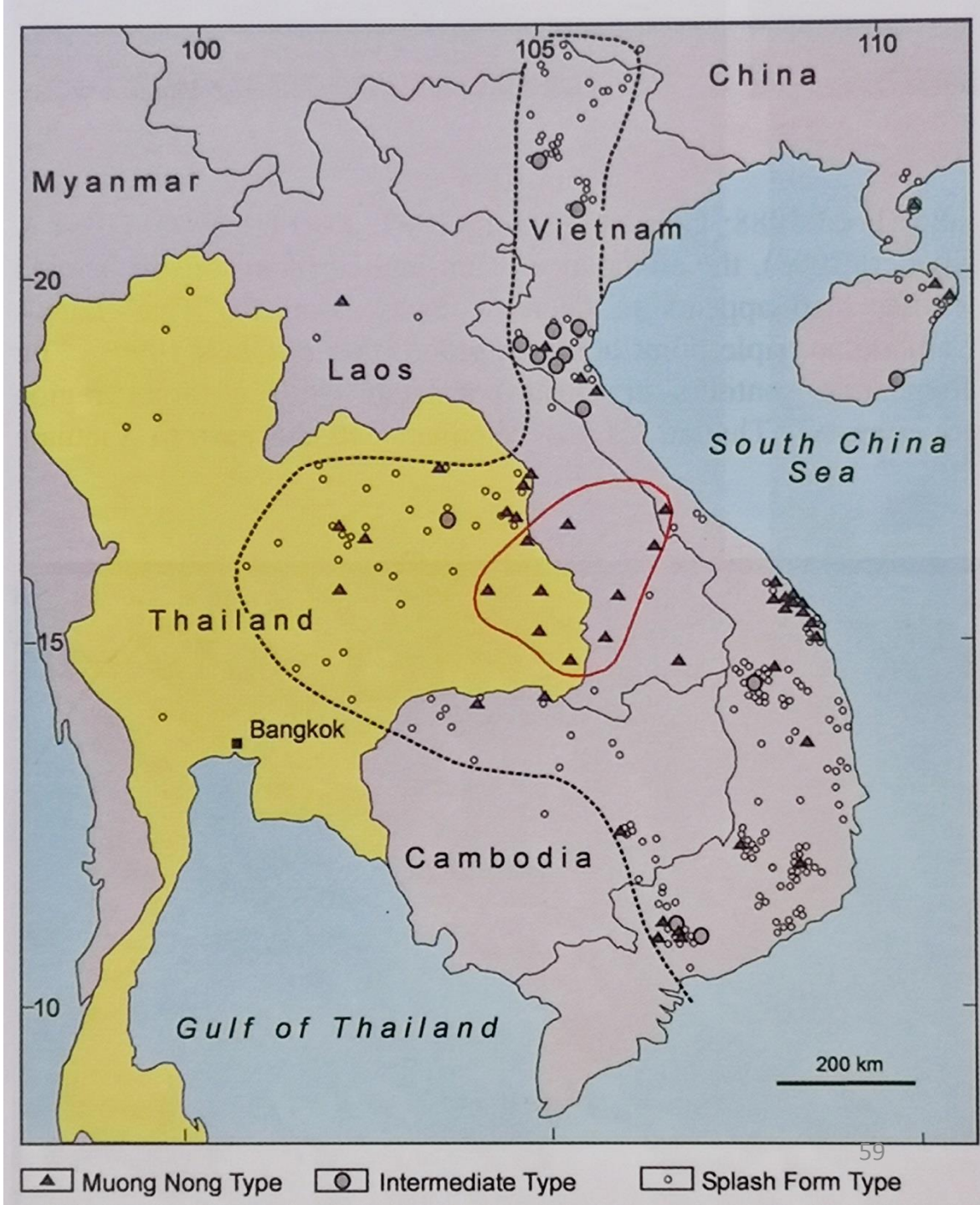
การกระจายตัว ของเทคไทต์ (800 ka) แต่ละชนิด ในไทยและเพื่อนบ้าน

Howard, 2011

Buntharik Event

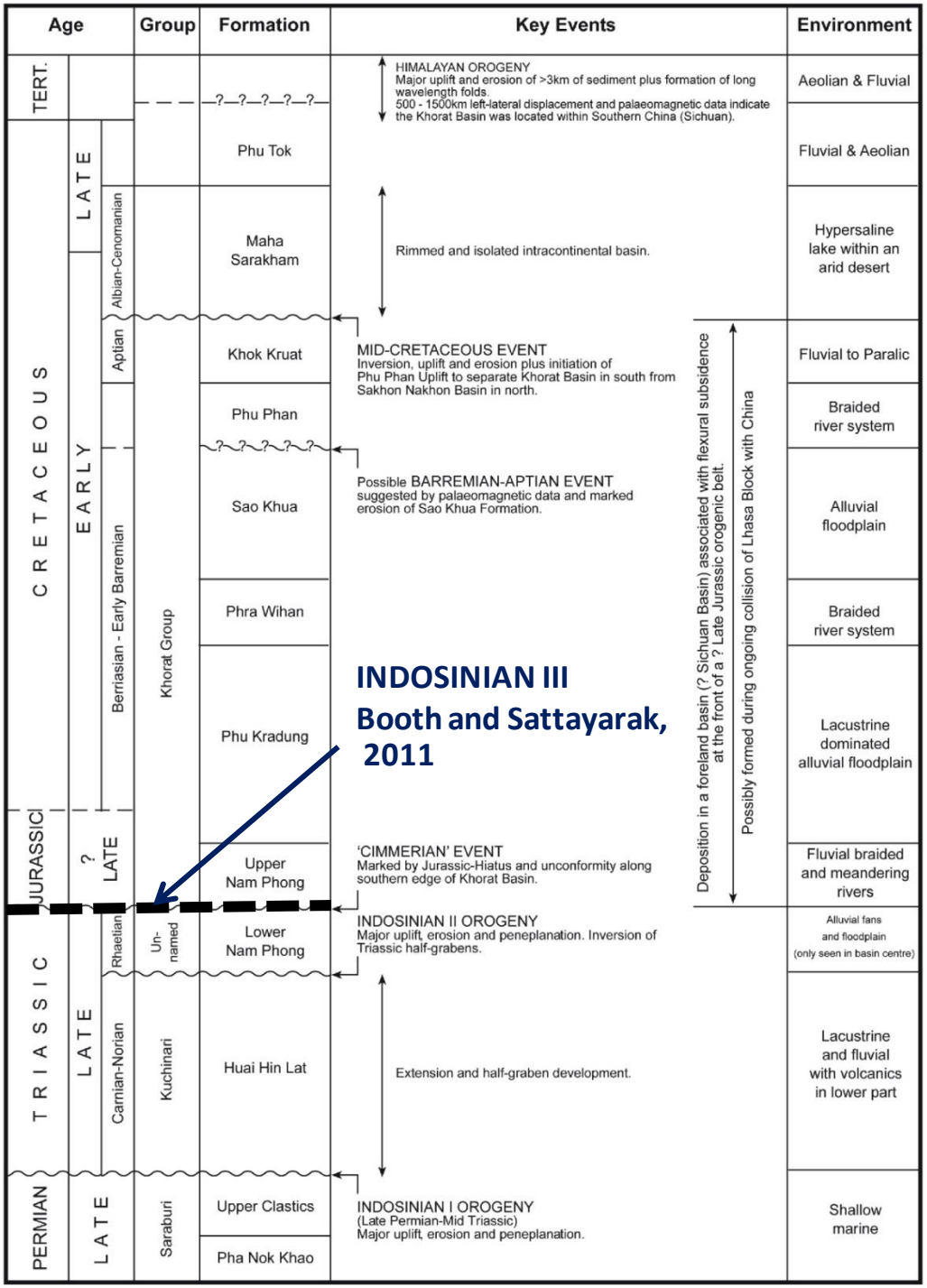
Catatoloess

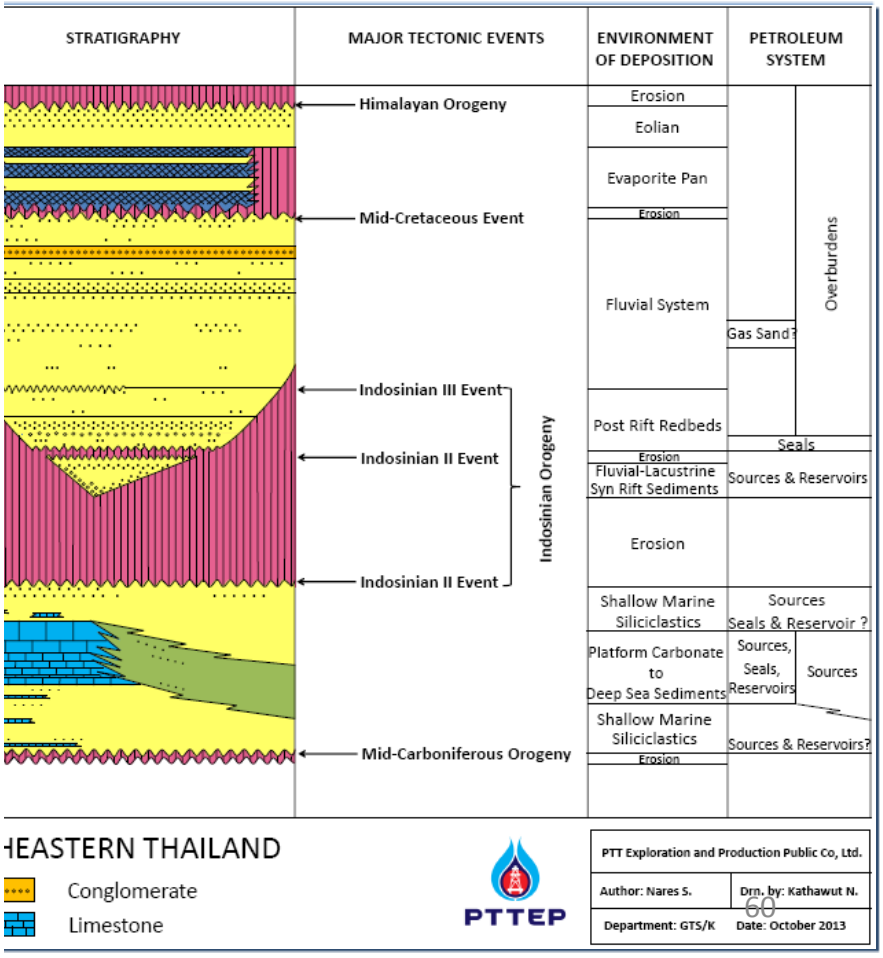
Bunopas, 1999



Racey,2010

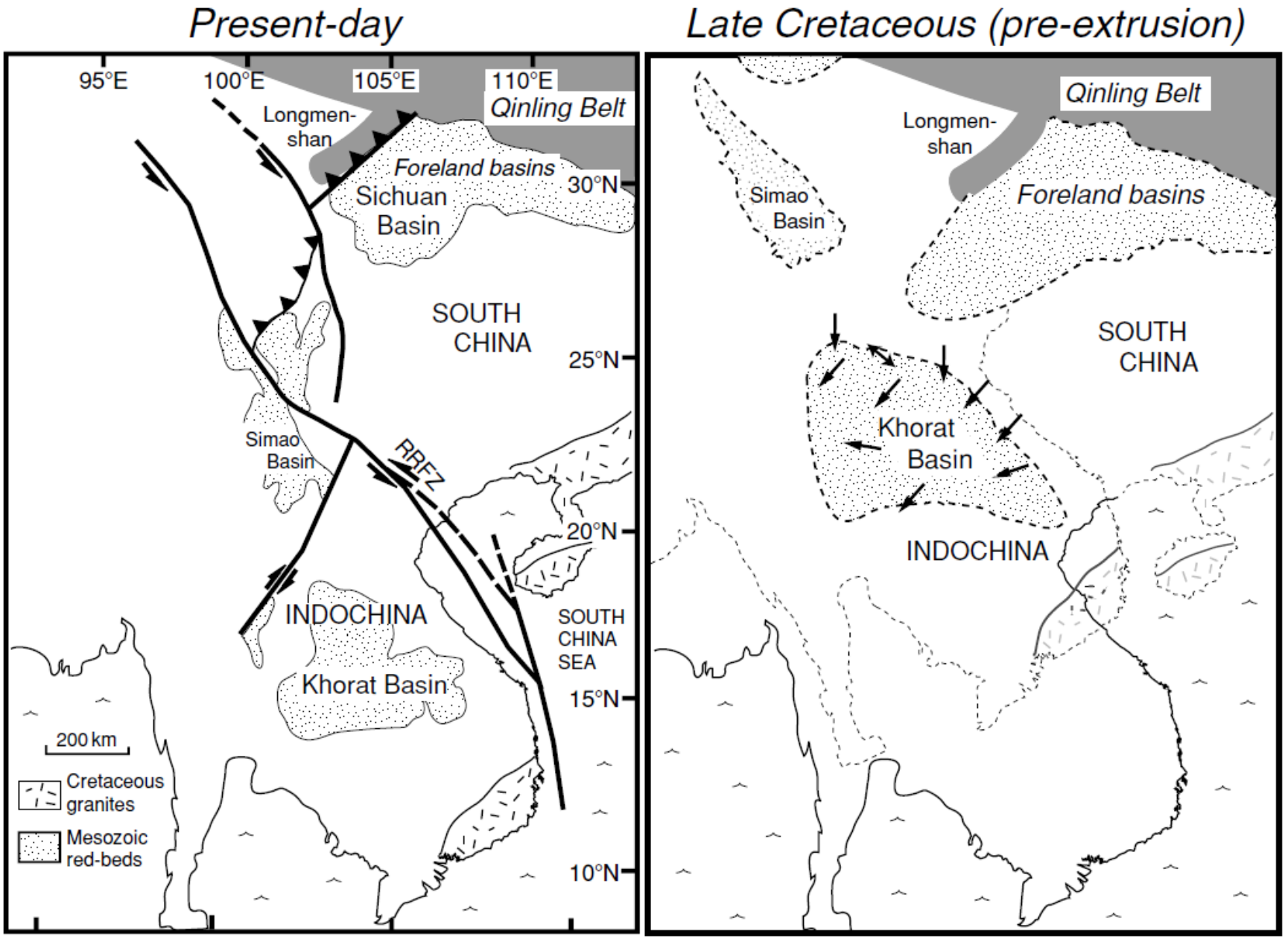
ratigraphy of Northeast Thailand





Present Day Location and Restoration of the Basin to pre-Extrusion Location

Carter and Bristow, 2003



Content

1. ISAN is Geol nt
   from Othe
2. What Kind ath ISAN ?
3. How Does ?
4. Was Indos ed ?
5. How Did 2 nt U ?
6. What ype tary Basin ?
7. Is Mah Sara ?
8. What is the ok Desert ?
9. Why Khora ed ?
10. How 16 ound in Khorat ?
11. How to Explain Young Geohazard in ISAN

Q&A