Cenozoic Tectonic Evolution of Northeastern Thailand

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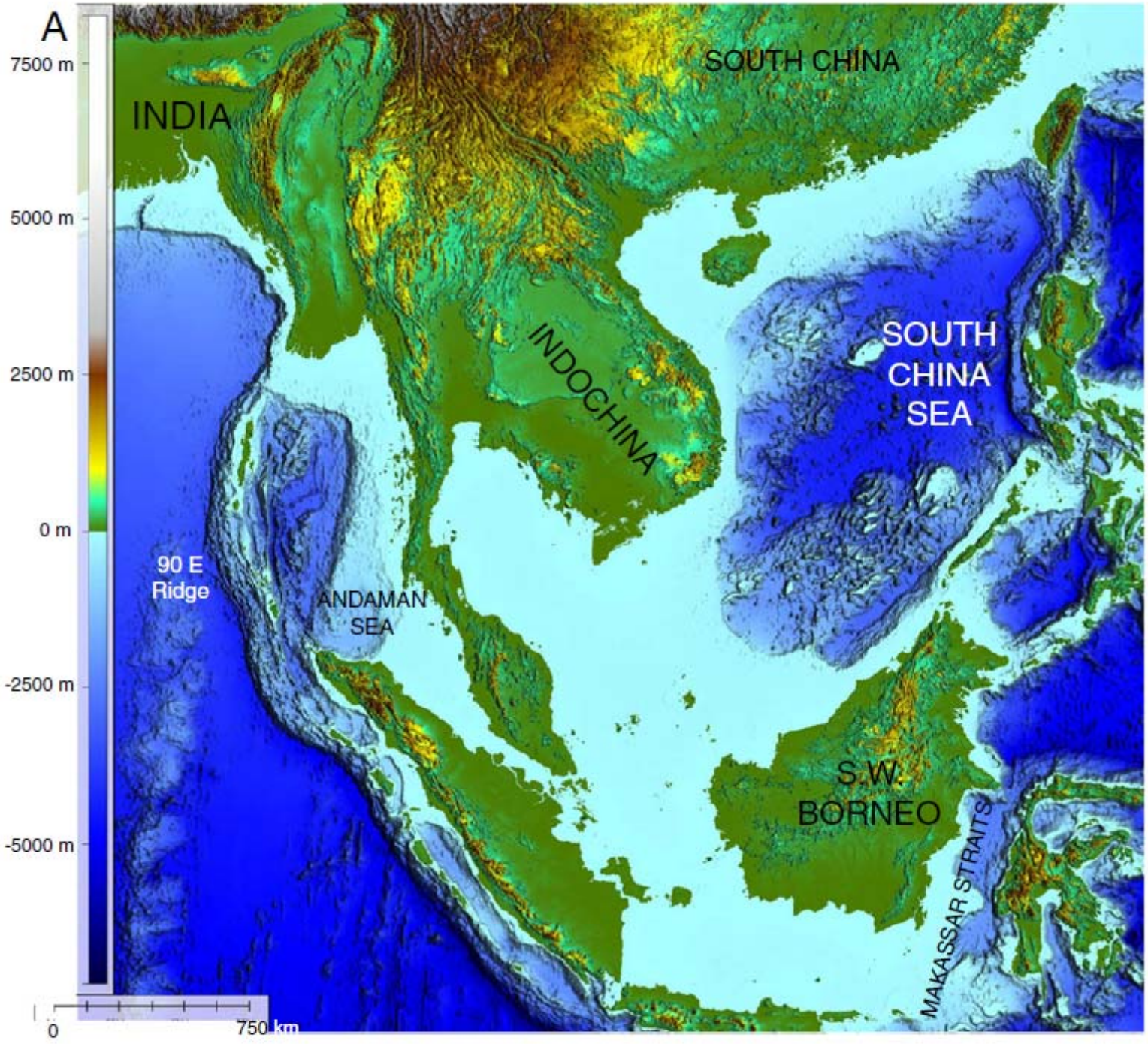
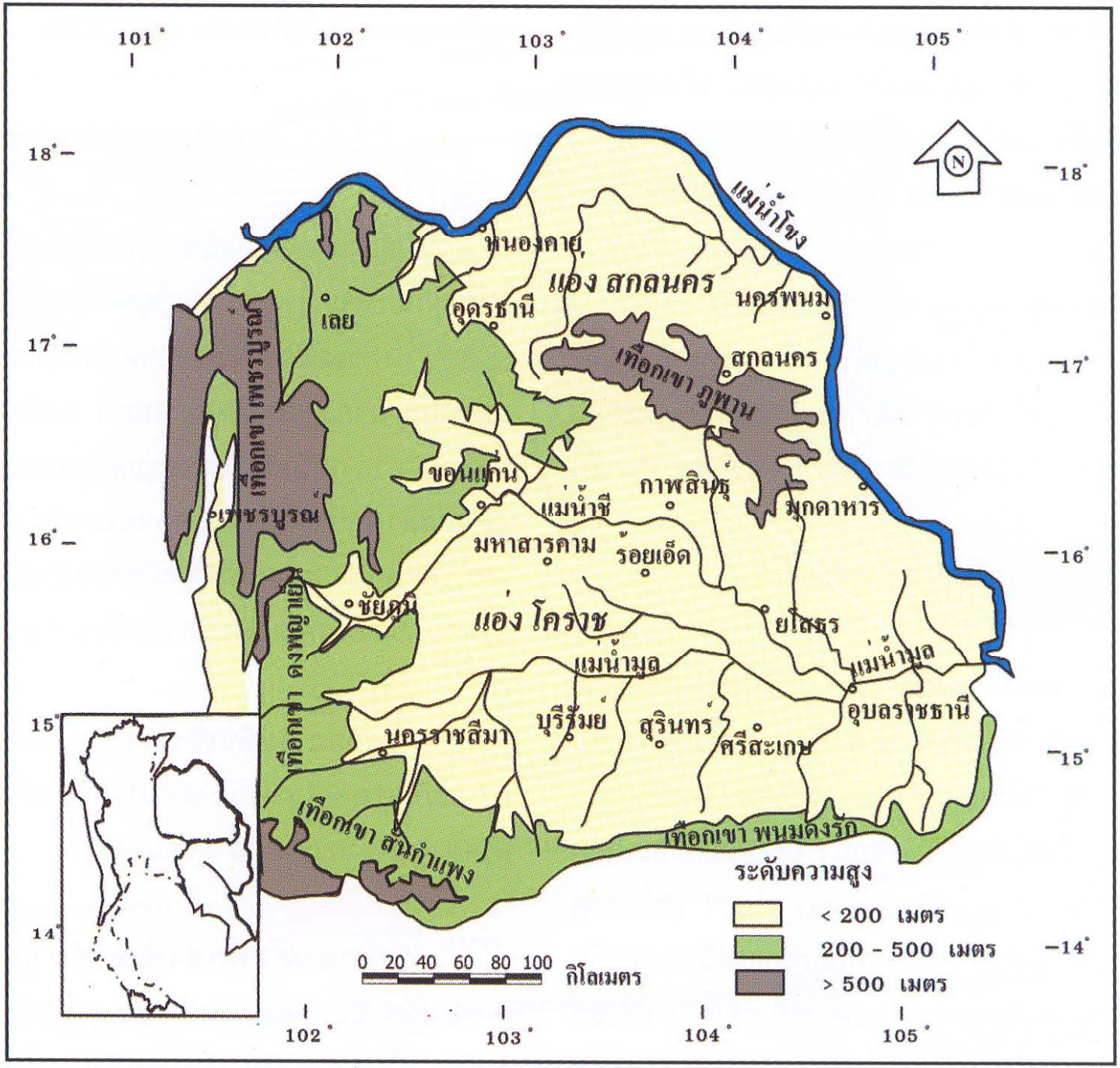
Seminar on Quaternary Geology of Northeastern Thailand organized by RIPM 19 Nov 2012


A
7500 m
5000 m
2500 m
0 m
-2500 m
-5000 m
INDIA
SOUTH CHINA
INDOCHINA
SOUTH CHINA SEA
90 E Ridge
ANDAMAN SEA
S.W. BORNEO
MAKASSAR STRAITS
0
750 km

Topics

- About the Khorat Plateau (Esan Physiography and pre-Quaternary geology)
- Methodology

  (Remote sensing, geomorphology, stratigraphy, geochronology)
- Our Results (Basalt of southern Esan, Tektite ages and Ongkarak Fault)
- Discussion (Climate and environmental change and Thakaek Fault)



Introduction : Physiography

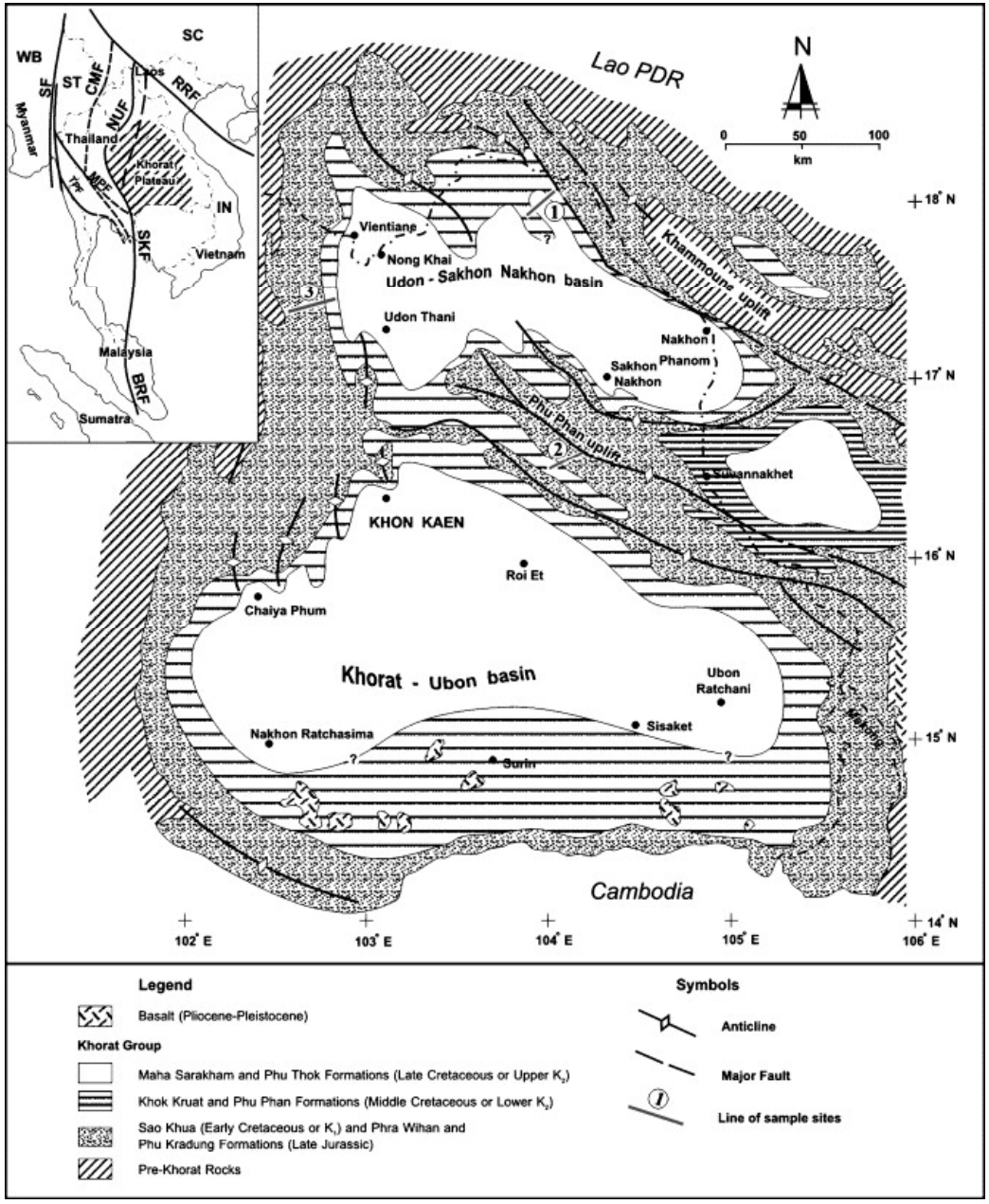
Khorat Plateau with the elevation of about 200-250 m msl

2 basins Sakon Nakhon Basin and Khorat _Ubon Basin

Khao Phupan

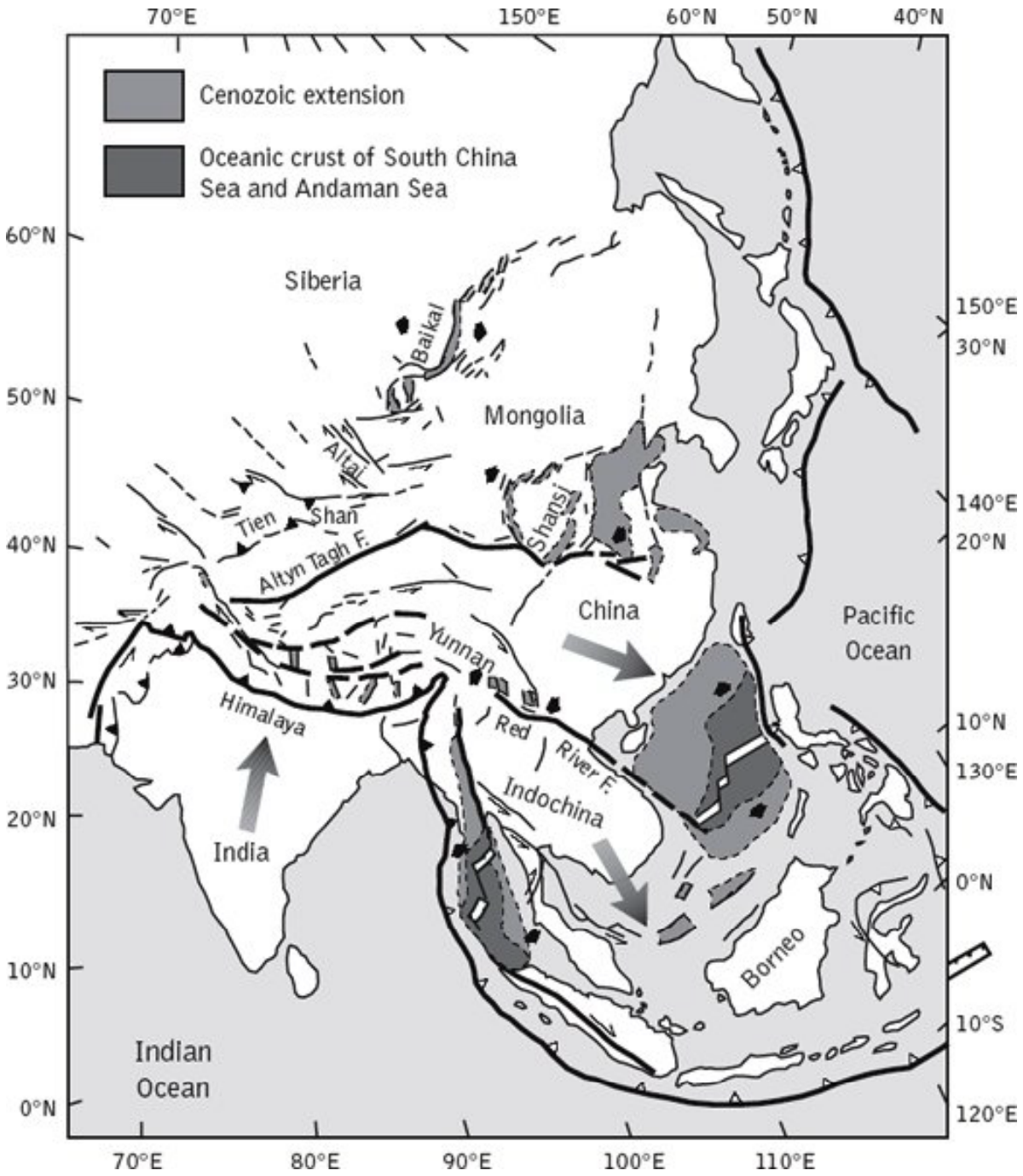
Introduction

- ESAN (or NE Thailand) terrain is the outstanding landscape because it consists of the ~3 km thick, subhorizontal sedimentary strata of the Khorat Group



Charusiri et al. (2009)

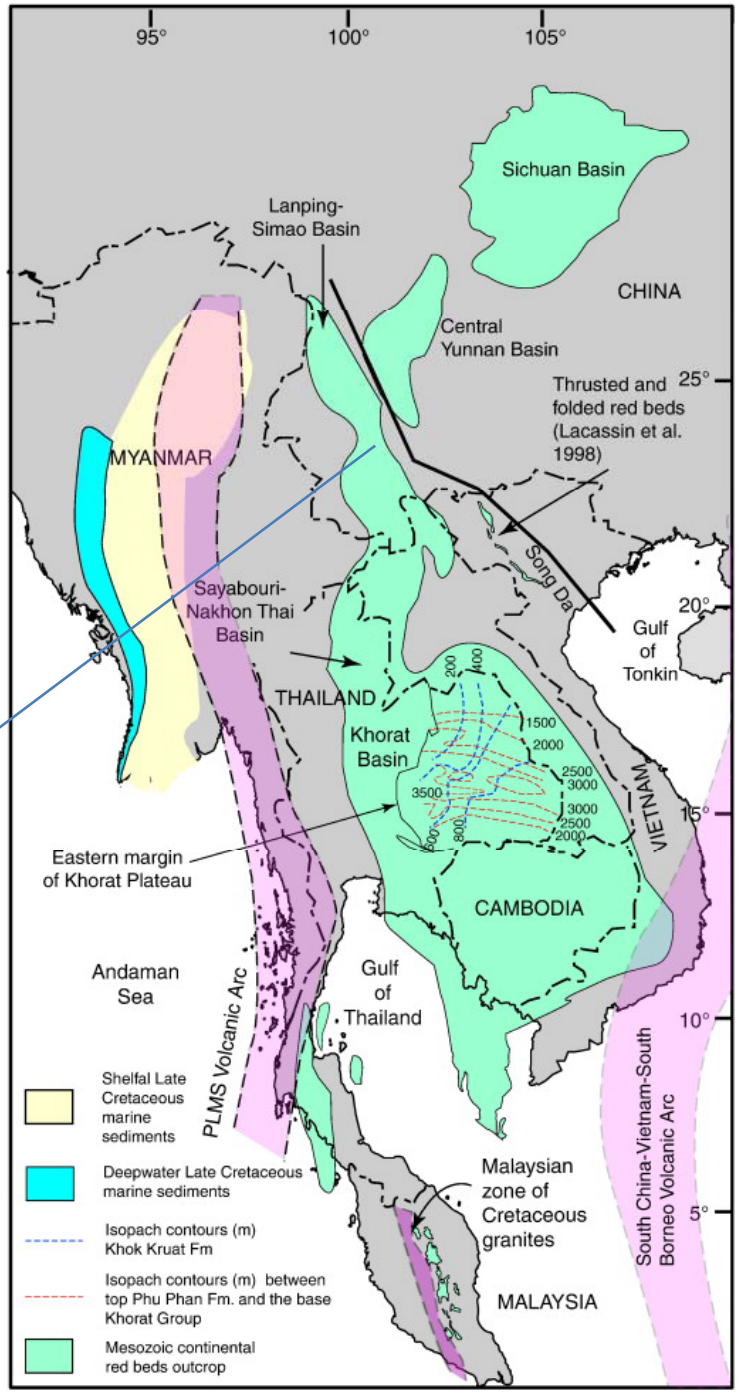
India – Asia collision after 45 Ma



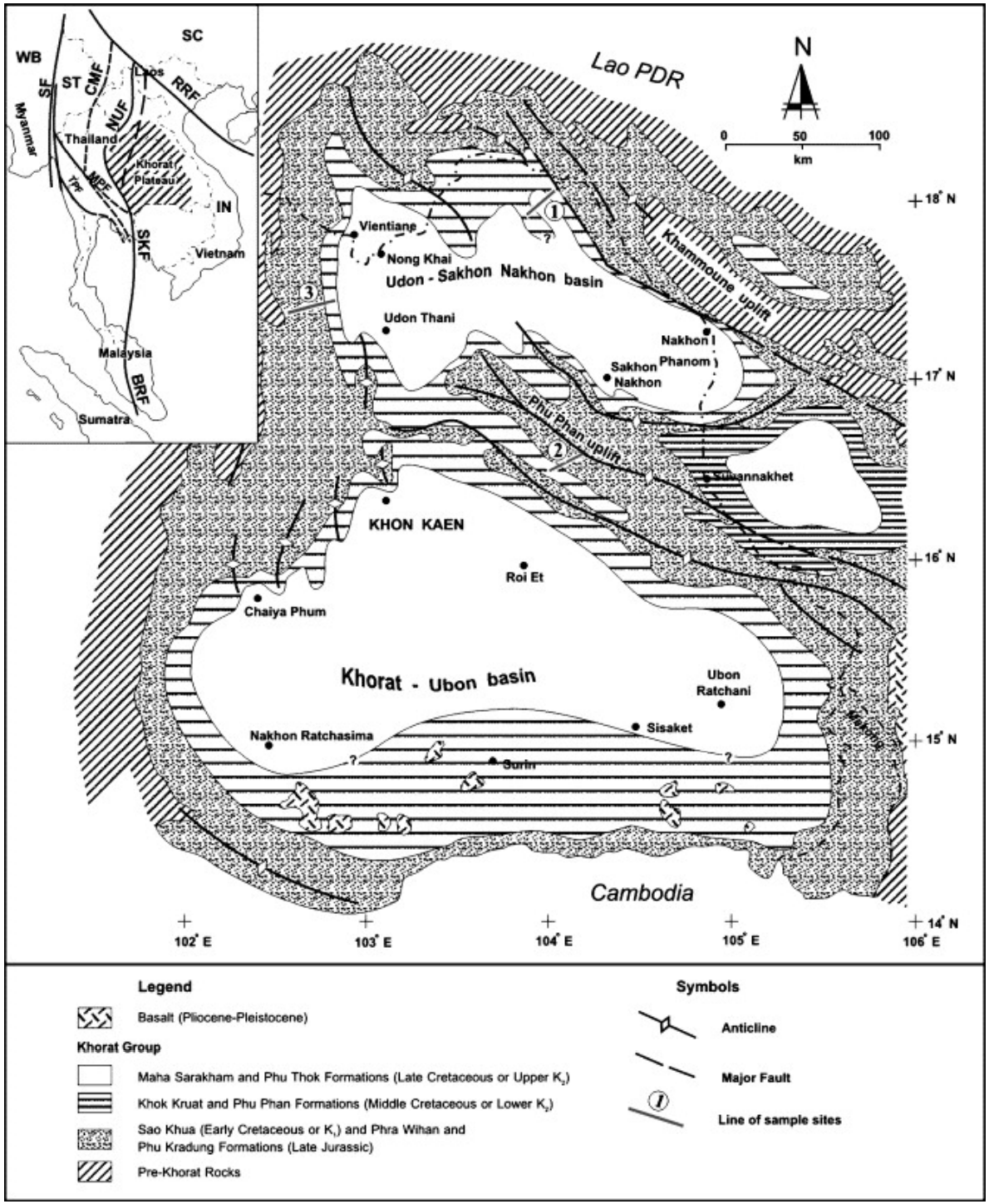
Indochina and Simao Terranes

- Khorat Group continental rocks of the Indochina terrane (ESAN) can be correlated with those of the Lanping-Simao terrane

Morley (2012)



Khorat is a large flat area with higher elevation than its surrounding region

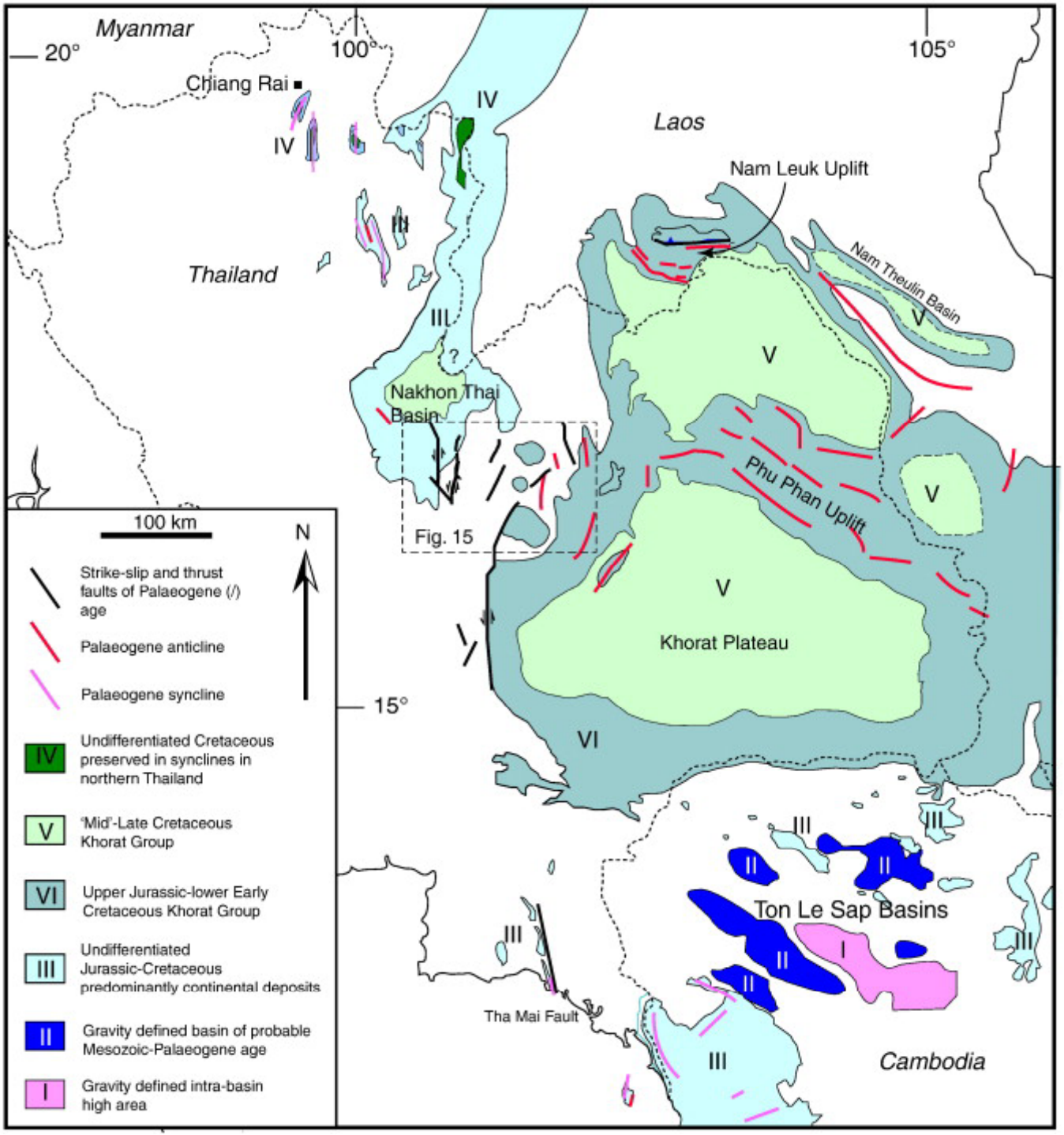


Methodology

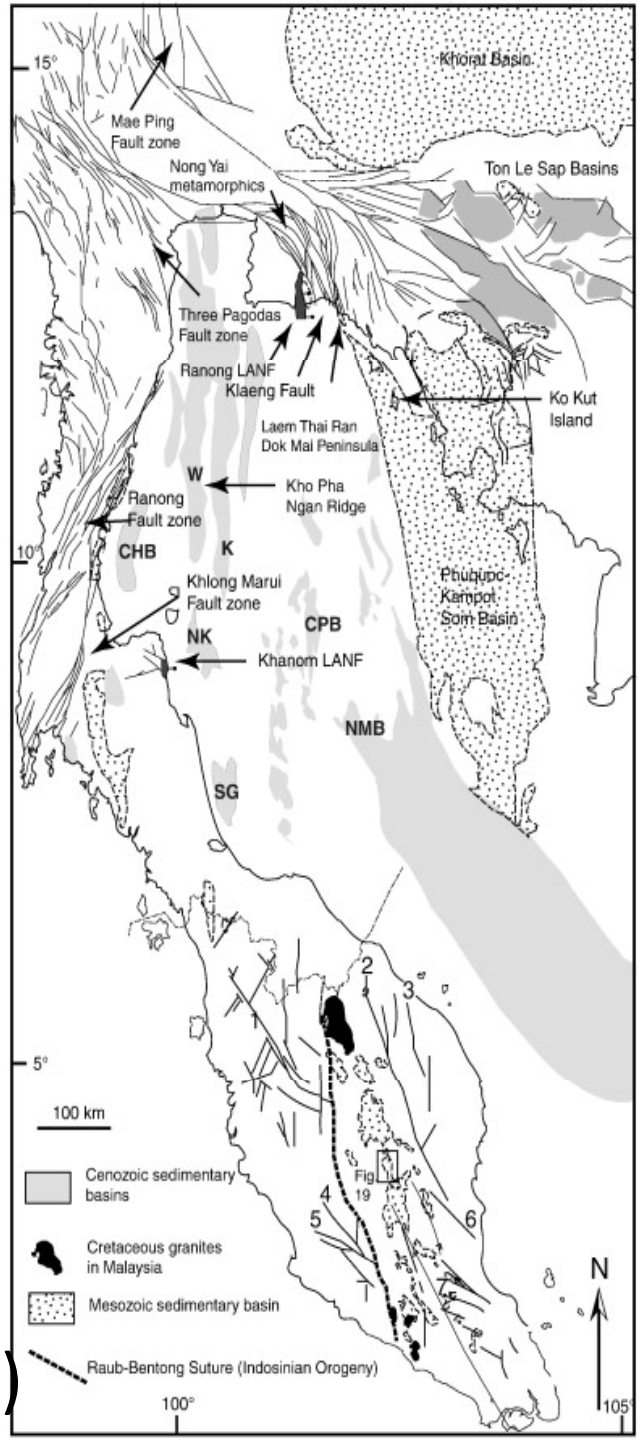
- Remote sensing information
- Geology and Stratigraphy
- Geomorphology
- Geochronology

The NW-SE trending large and broad fold structures affect the Khorat Group of the Khorat Plateau and nearby areas.

Morley (2012)

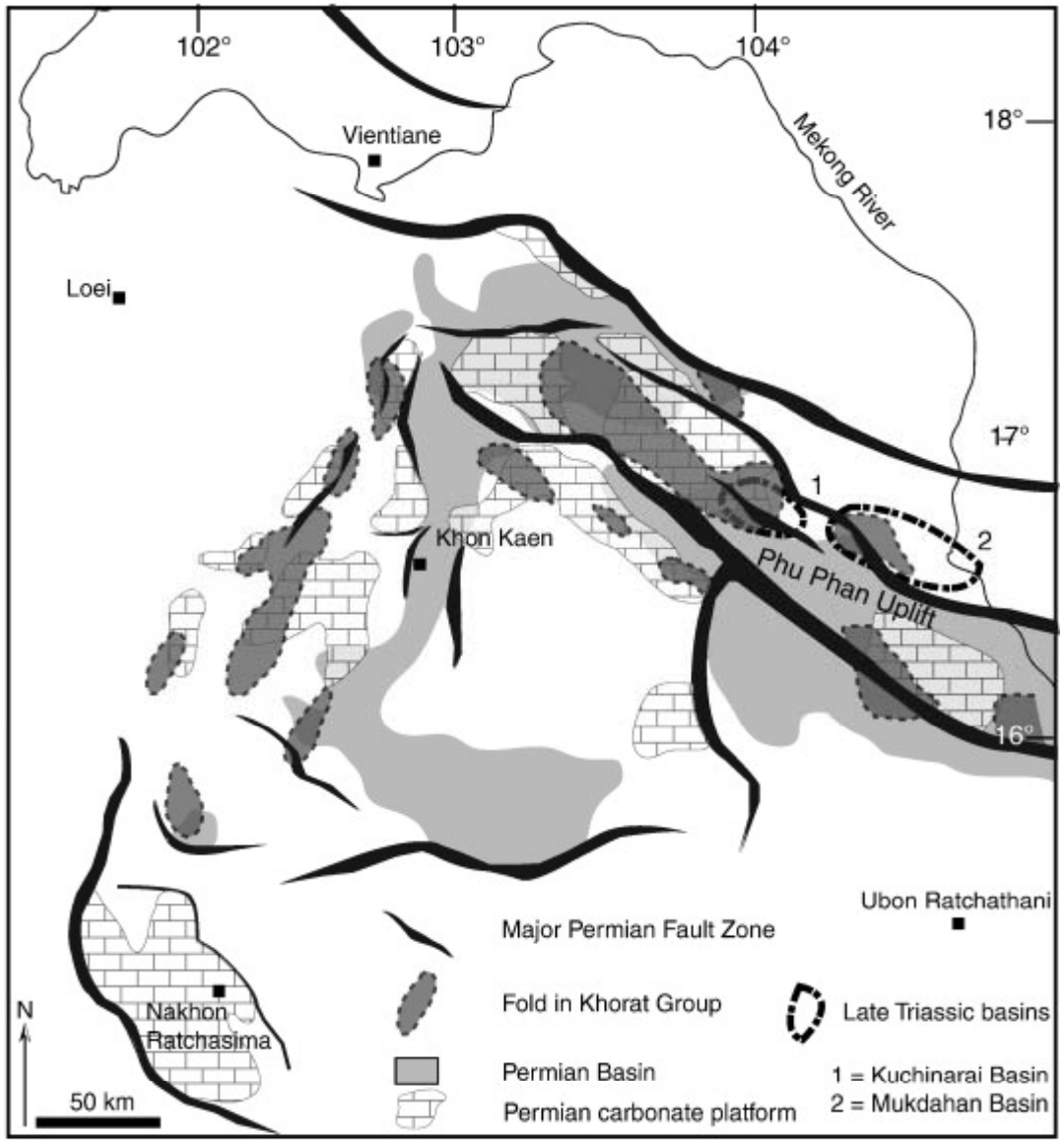


The western edge of the Plateau marks a transition between the more intense structures of northern and central Thailand and the Plateau, producing a widespread uplift and erosion of the Khorat Group rocks



Morley (2012)

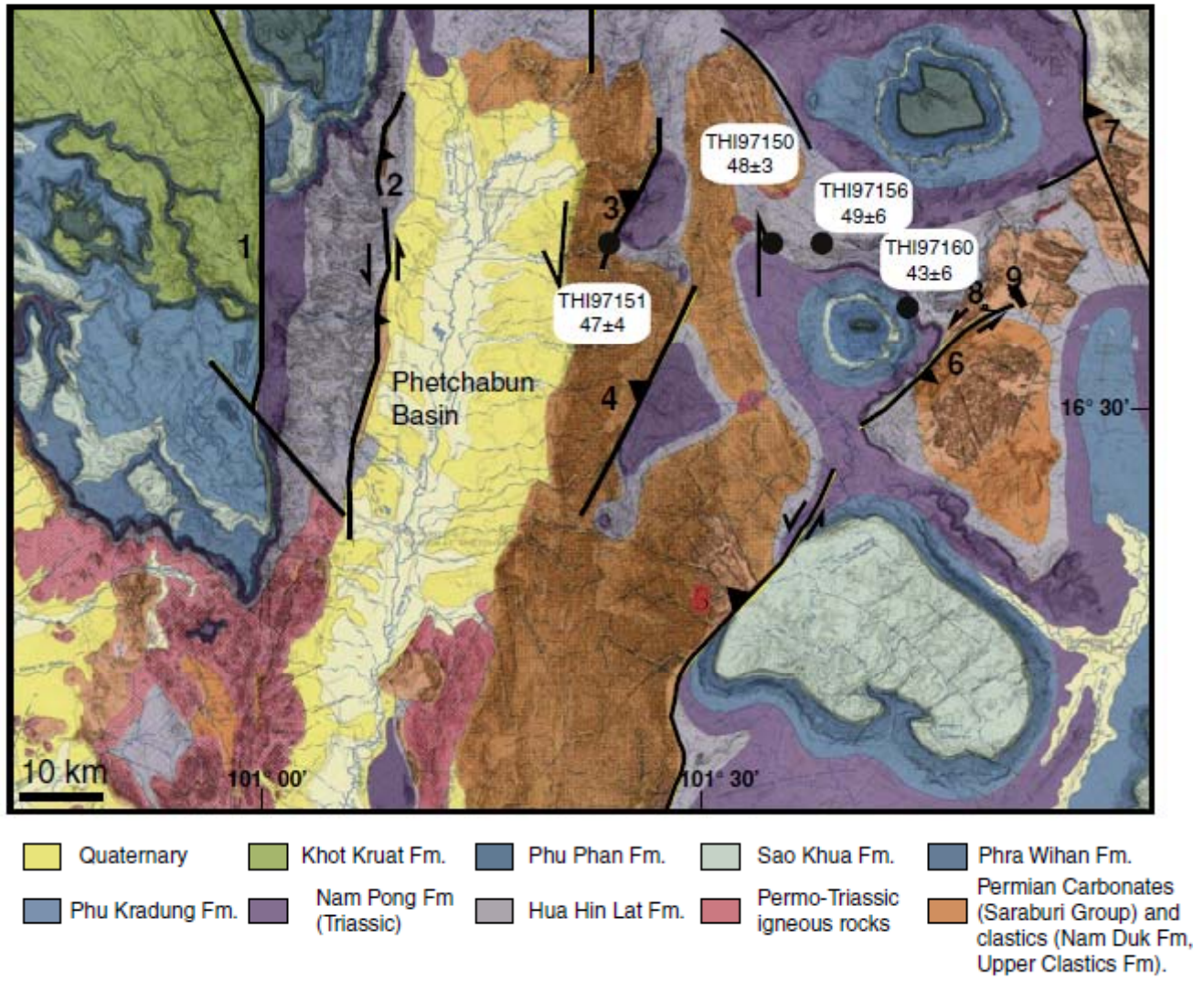
The deformation in the Khorat Group can constrain between a cessation of Cretaceous deposition (70-80 Ma) and the onset of rift basin development (± 30 Ma).



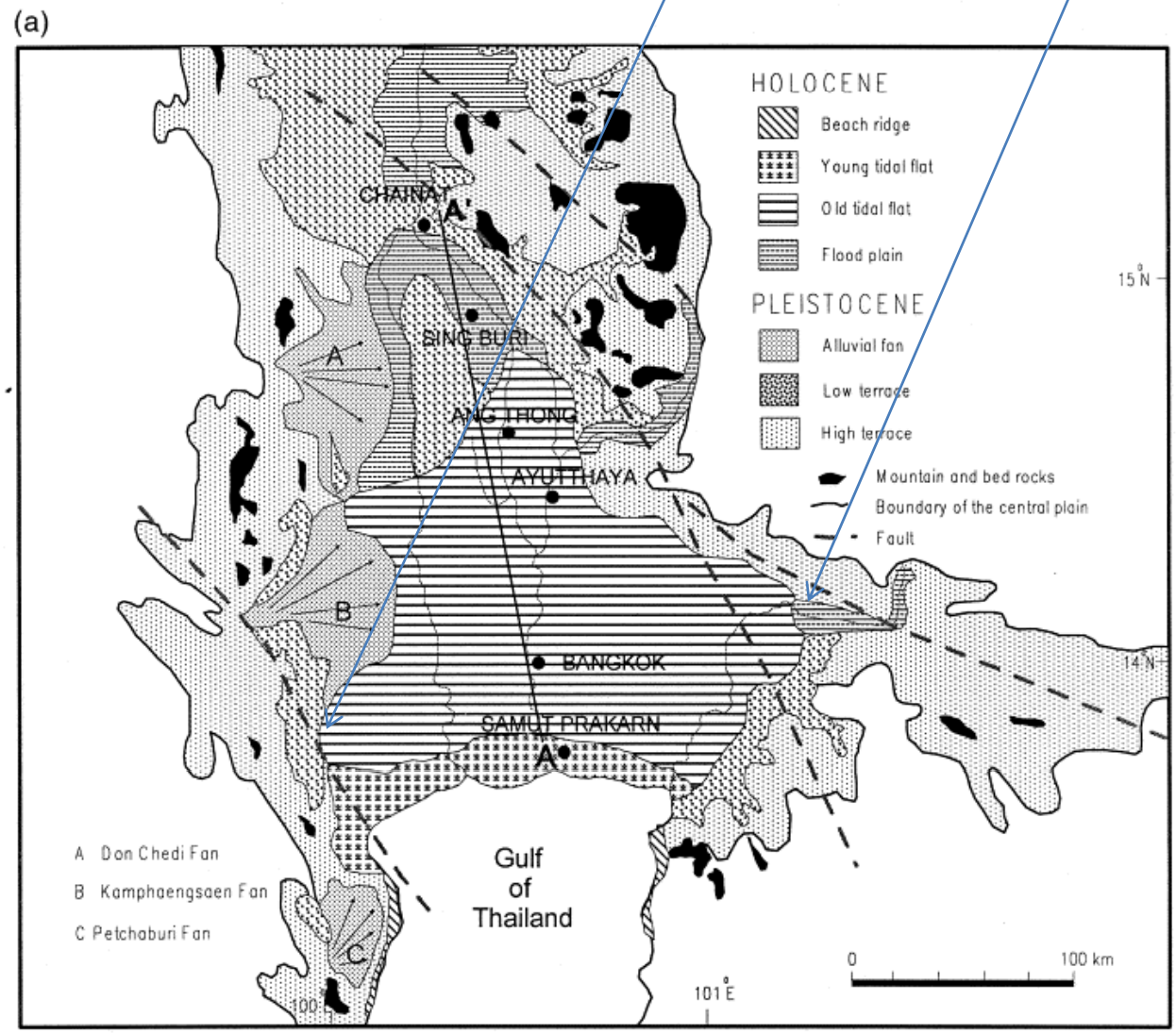
The uplift associated with foldings in the Plateau may have occurred during 40 Ma, suggesting Paleogene compressional setting was an essential tectonic event in the Plateau and nearby regions

DMR map

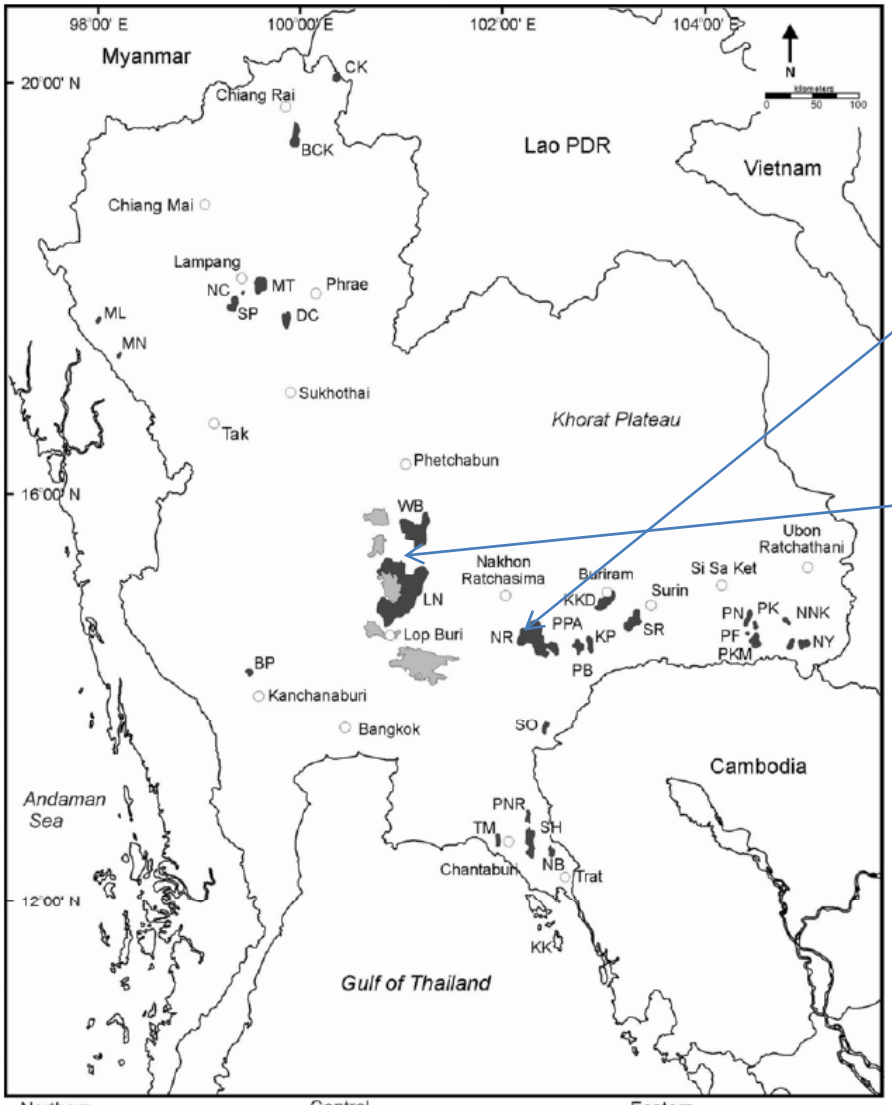
AFT by Upton (1999)



Such uplift and tilting of the Khorat are inferred to be associated with sinistral movement along the reactivated Three-Pagoda and Mae Ping Faults.



Modified after Sinsakul (2000)



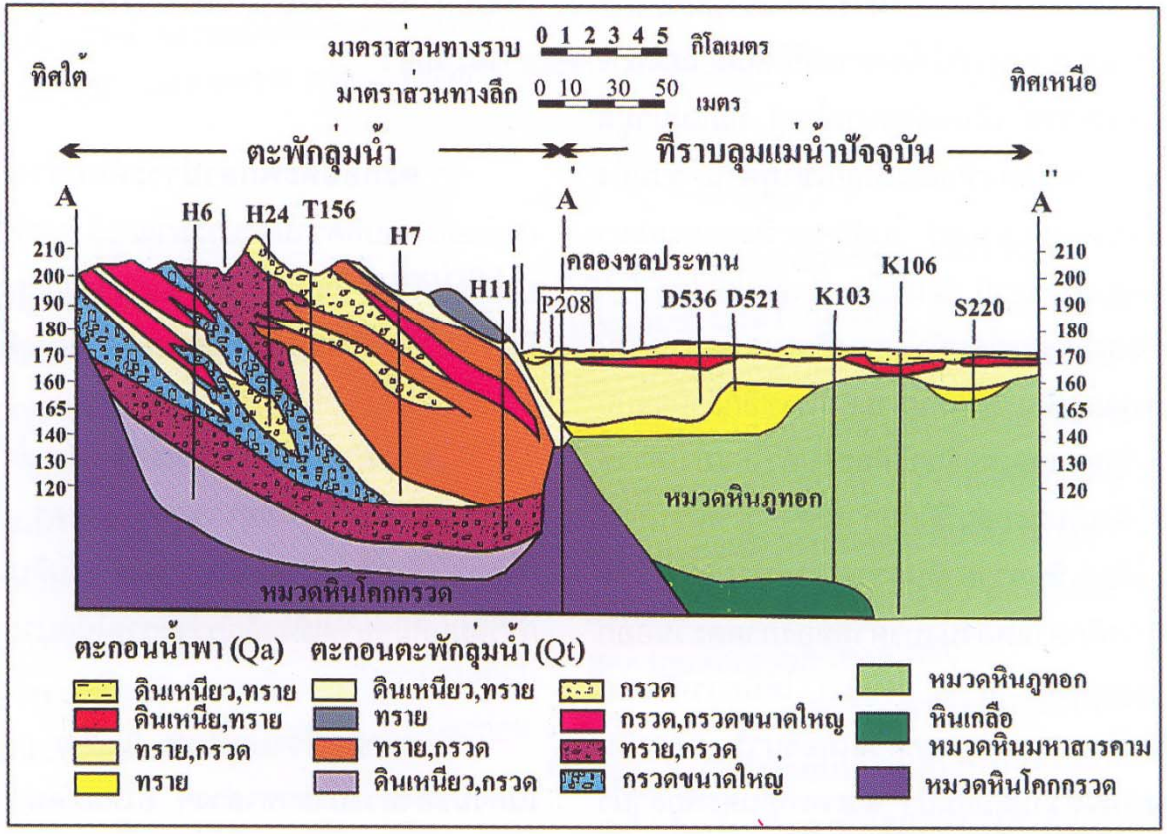
Northern		Central		Eastern	
CK	Chiang Khong	BP	Bo Phloi	NR	Nakhon Ratchasima
BCK	Ban Chang Khian	WB	Wichian Buri	PPA	Phu Phra Angkhan
ML	Mae Lama	LN	Lam Narai	KKD	Khao Kradong
MN	Mae Ngao			KP	Khao Pha Nom Rung
MT	Mae Tha	Southeastern		PB	Prai Bat
NC	Ban Nong Nam Cho	TM	Tha Mai	SR	Surin
SP	Sop Prap-Ko Kha	PNR	Pong Nam Rong	SO	Sae O
DC	Den Chai	SH	Saphan Hin	PN	Phu Ngoen
		NB	Nong Bon	PF	Phu Fai
		KK	Ko Kut	PKM	Phu Khmit
				PK	Phu Kom
				NNK	Nong Nam Khun
				NY	Nam Yun

Fig. 13.2 - Barr & Charusiri

During 1 -3 Ma, E-W trending mafic magmatism was generated in southern ESAN and during 0.7 to 24 Ma, N-S trending bimodal magmatism in southern ESAN

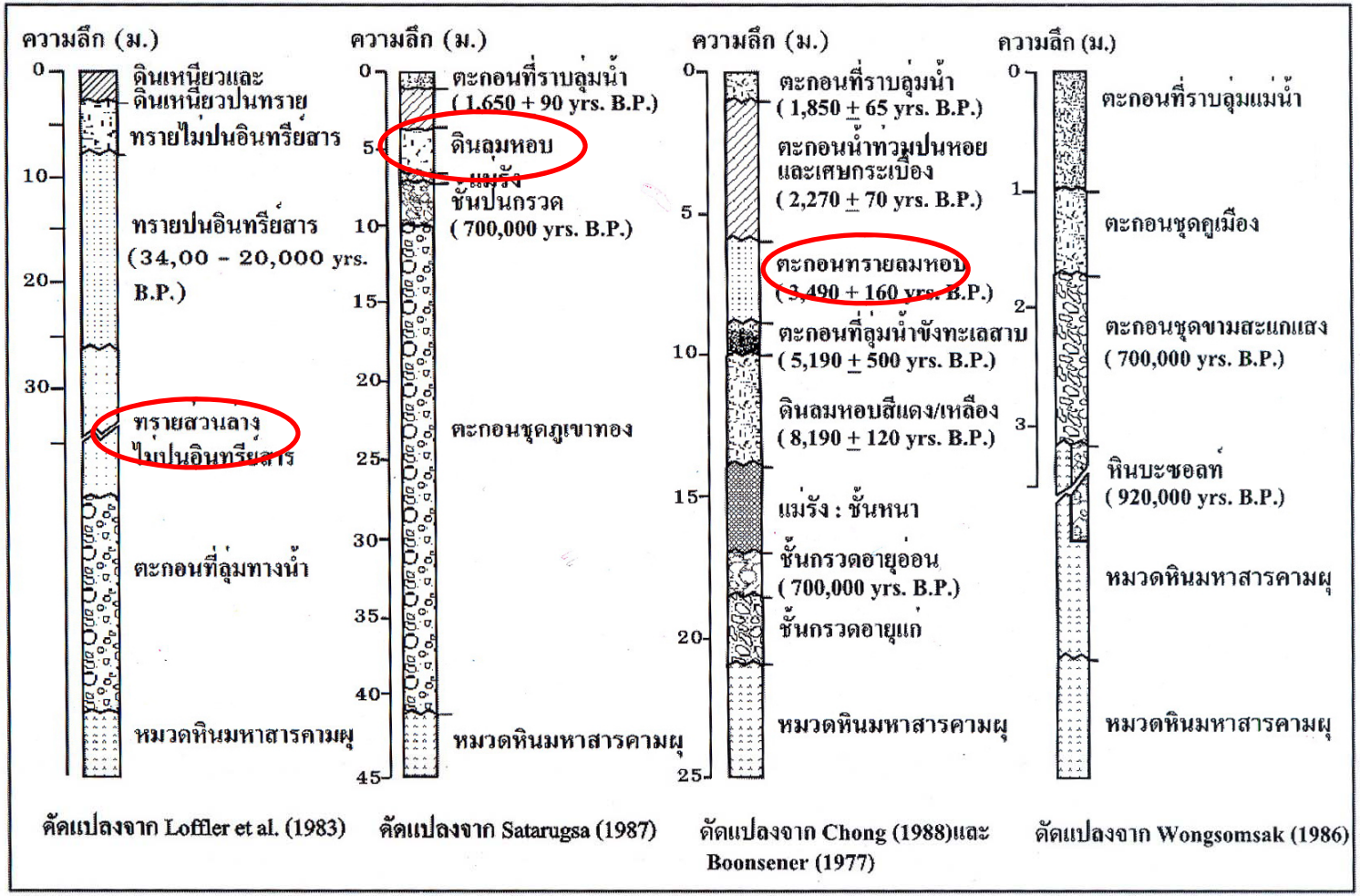
both occurred as a result of continental rifting in the southern Khorat Plateau and may have caused tilting of the southern ESAN

Mun and Chi Rivers of the Plateau were gradually developed and continued tilting may have generated small alluvial terraces



รูปที่ 7.31 ภาพตัดขวางตัวอย่างที่แสดงองค์ประกอบของตะกอนร่วนยุคควอเทอร์นารี ของภาคตะวันออกเฉียงเหนือที่ประกอบด้วยกลุ่มตะกอนที่ราบลุ่มแม่น้ำและกลุ่มตะกอนตะพักลุ่มน้ำ (คัดลอกจาก Wongsawat *et al.*, 1992)

Stratigraphic correlation of Quaternary sediments in Khorat Plateaqu (Nutalaya et al., 1989)



0.78 – 0.8 Ma meteorite impact may have taken place onto the Plateau causing voluminous catastroloess and dust sediments all over the Plateau,.

“the Buntharik astrogeological event” caused by the “Euraustralasian cometary impact” (Bunopas et al., 2007, 2009)

Dating of tektites reveals the age of the event between 0.709 - 0.770 ± 0.020 Ma (Blum et al., 1992; Gentner et al.. 1967; 1969; Izett and Obradovich, 1992 and Zahringer, 1963).

- Large tear drop or perhaps Flintstone's fighting tool from Chum Phae, Khon Kaen. (2.5-1.0) width X 11.0 long cm
- Comet track

Impact: Tektite products and their effect

Buried petrified burnt tree in the contemporaneous mudflows and avalanches with gravels at south Khorat at a terrace at Ban Krok Duen Ha. A splashed tektite specimen was found embedded in the mudflow covering the tree. The terrace gravels marked the impact surface, seen under nearby catastroloess

Fragmented layered tektites mainly from Buriram, northeastern Thailand, collected by Howard during 2002.

Thailandite tektite

Than Chang Sandpit near Nakhonratchasima city:

TL Ages of tektites ~0.8 Ma and those of the thick sequences of Quaternary /Neogene sand deposit from 0.1 to 0.4 Ma

The Symposium on Geology of Thailand
26-31 August 2002, Bangkok, Thailand

Quaternary Tektites and Their Sediment Hosts at Ban Tachang Sand Pit, Chaloem Prakiat, Nakhon Ratchasima, NE Thailand: Stratigraphy and TL Ages.

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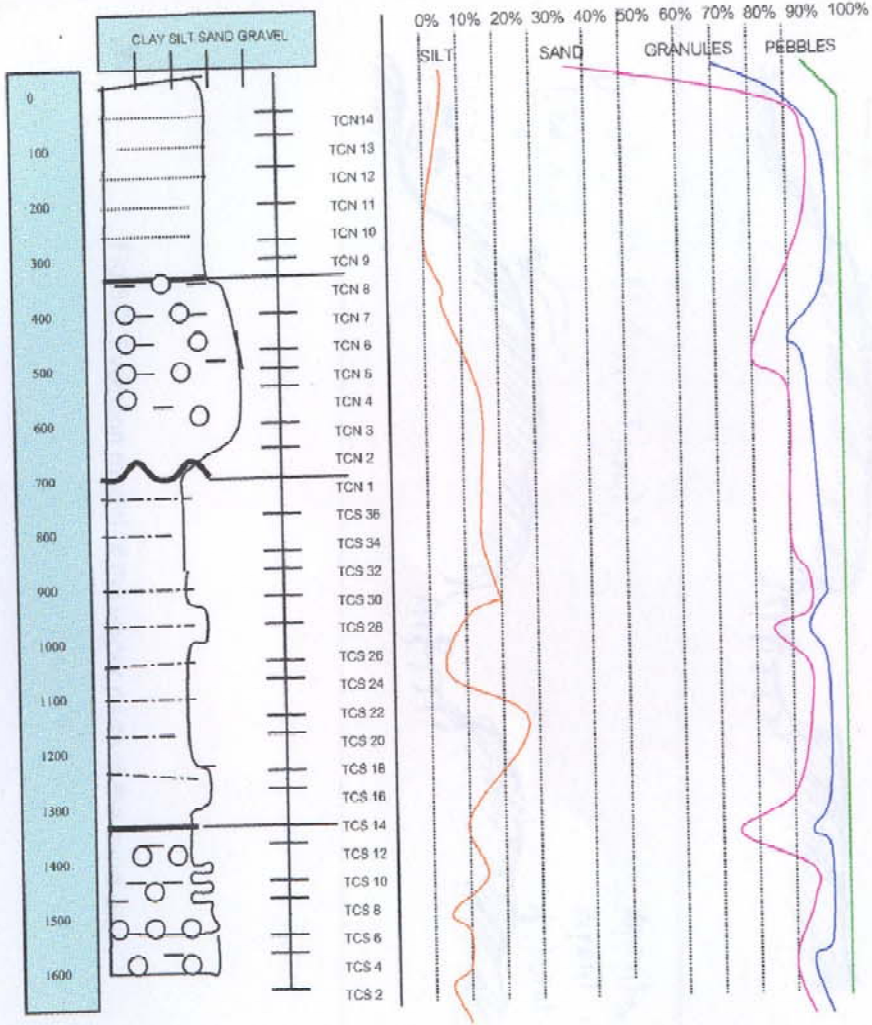
EXTENDED ABSTRACT

A 7-7.77 m-thick measured section through the currently operated sandpit in Ban Tachang, Nakhon Ratchasima, was stratigraphically investigated from a topsoil surface. Six units of semi- to un-consolidated deposits were described, studied geochronologically, and examined for hosting tektites. Unit 1 (av.0.5 m thick) immediately beneath the topsoil layer consists chiefly of brown, well-sorted, well-rounded silty clay layer. Unit 2 (av.0.5-m thick) comprises mainly pale brown, vertically graded bed of gravel to silt-size sediments with subangular and bad-sorting characters. Unit 3 (av.2.56-m thick) is composed essentially of pale brown, quartz-rich gravel to coarse sand, with sporadic tektites, burnt tree trunks, and clay lenses. Unit 4 (av.1.5-m thick) consists chiefly of pale brown, fine to fine to medium sand with subroundness and moderately good sorting. Unit 5 (av.1.20-m thick) is composed entirely of black to dark gray clay to silty clay. Unit 6 (av.1.51-m thick) consists largely of gray to yellowish gray, silt to very fine sand with good roundness and good sorting.

A few Thailandite tektite samples were collected entirely from unit 3 of the sandpit. Three types of tektites were recognized on the basis of geometry including teardrop, dumbbell and circular. The tektites ranging in size from less than 0.5 mm to up to 5 cm were discovered in the 1-5 meter - thick pebble bed about 0.8 – 1.5 meter from a topsoil surface.

Individual sand-rich samples (av. 2 kg) were carefully taken almost at the middle part of each unit in almost dark shades. Six purified quartz concentrates (>95% modal volume) were extracted for thermoluminescence dating (TL). Dating method of these sand samples was applied following that of Takashima and Watanabe (1994), and measurement was performed at the Geological Survey Central Laboratory. TL date is calculated using the ratio of paleo-doses and annual doses measured from samples Values of paleo-doses for sand samples vary from 182 to 764 Gy, and those of the annual doses from 0.176 to 0.355 mGy/yr.



	Description	Possible Deposite Environment	Fossil	Age
TOPSOIL			water buffalo	Holocene
UNIT 1		Fluvialtite	-	Pliestocene
UNIT 2	✳ dominated sand, with a little wood & fossil	sheet flood	-	
UNIT 3	dominated gravel and sandy clay and with wood, & fossil	debris flow	rhinocerax	Pliocene
UNIT 4	dark sandy clay to silty sand, with fossil	sheet flood	-	Miocene
		sieve lobe		
		sheet flood	mastodon	
		sieve loobe	-	
		sheet flood	-	
UNIT 5	fine sand interbedded with wood fragments	debris flow	mastodon	

✳ Equivalent to the layer of this current investigation

Fig.5.1. Detailed stratigraphy of the studied sand pit at Tha Chang(modified after Nakchaiya,2002)

GeoIndo (Khon Khaen) conf. 2005

International Conference on Geology, Geotechnology and Mineral Resources of Indochina (GEOINDO 2005)
28-30 November 2005, Khon Kaen, Thailand

Ages of Layered Tektites and Tektite- Bearing Sediments in Buntharik Area, Ubonratchathani, Northeast Thailand

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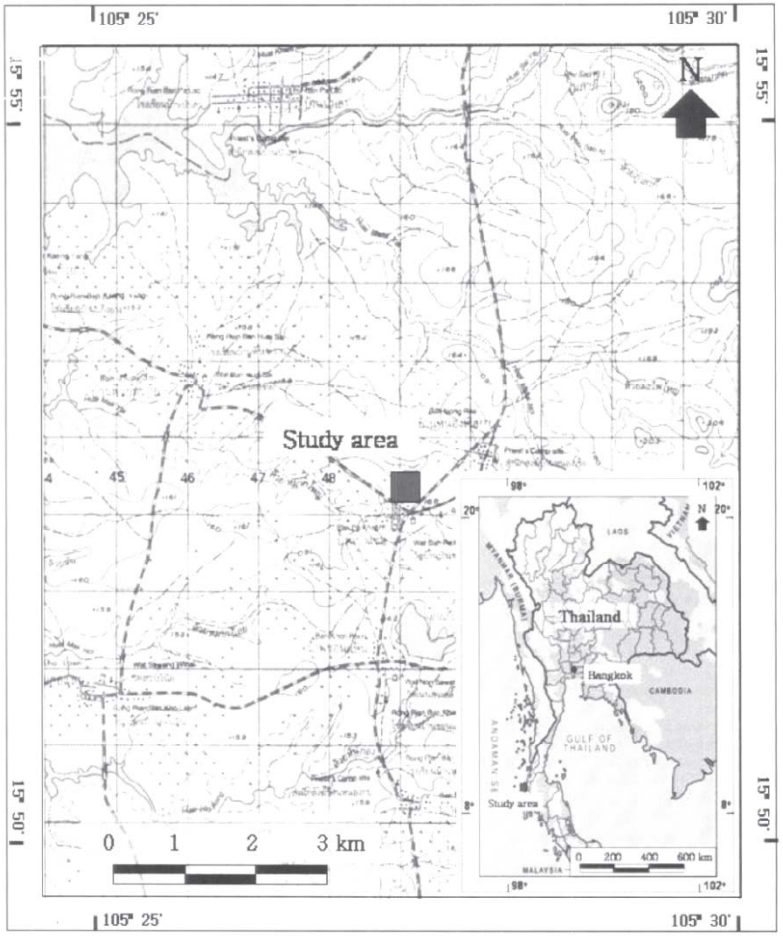
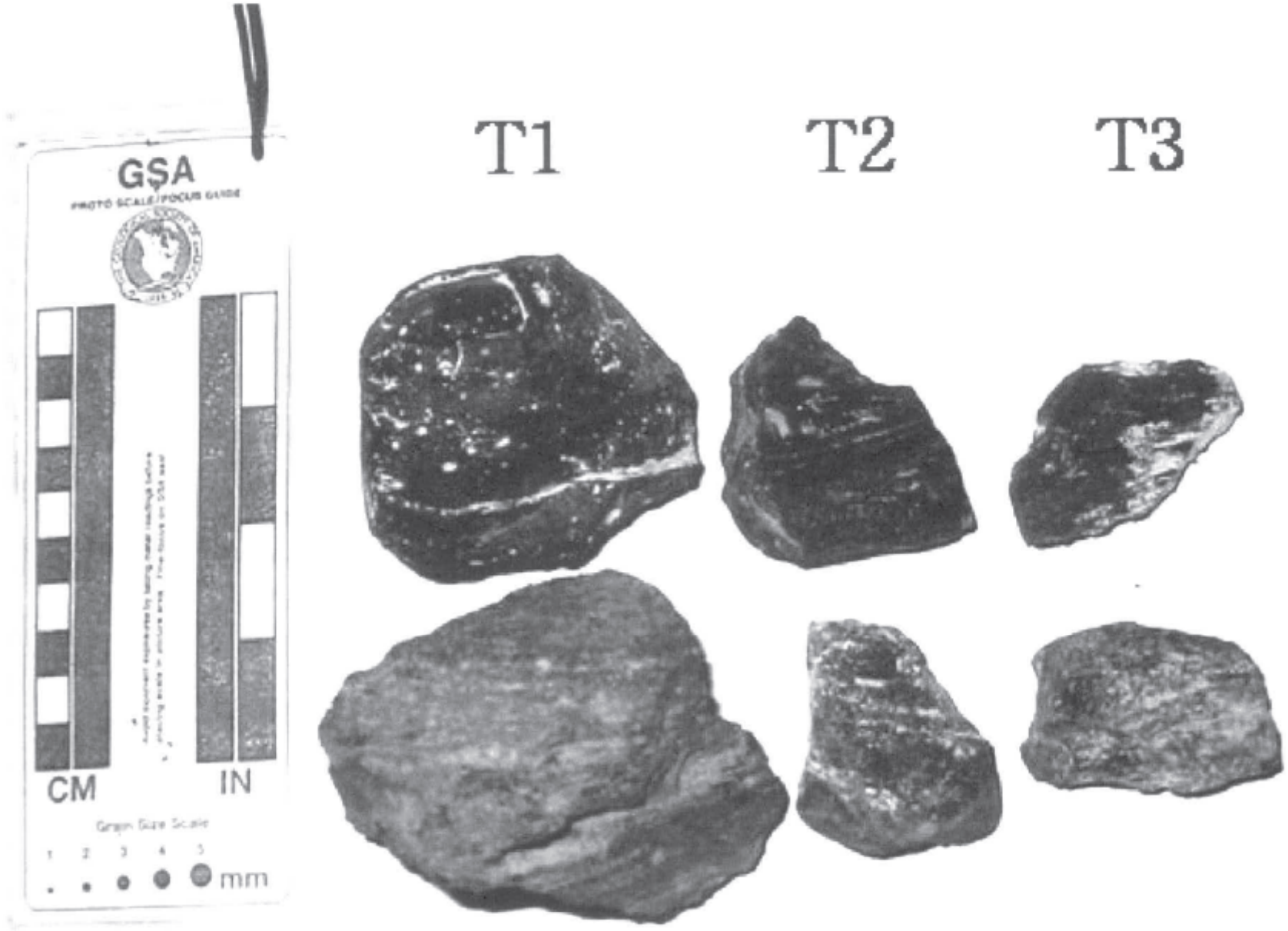
Location of Buntharik tektite in Ubonratchathani




GSA
CM
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T1
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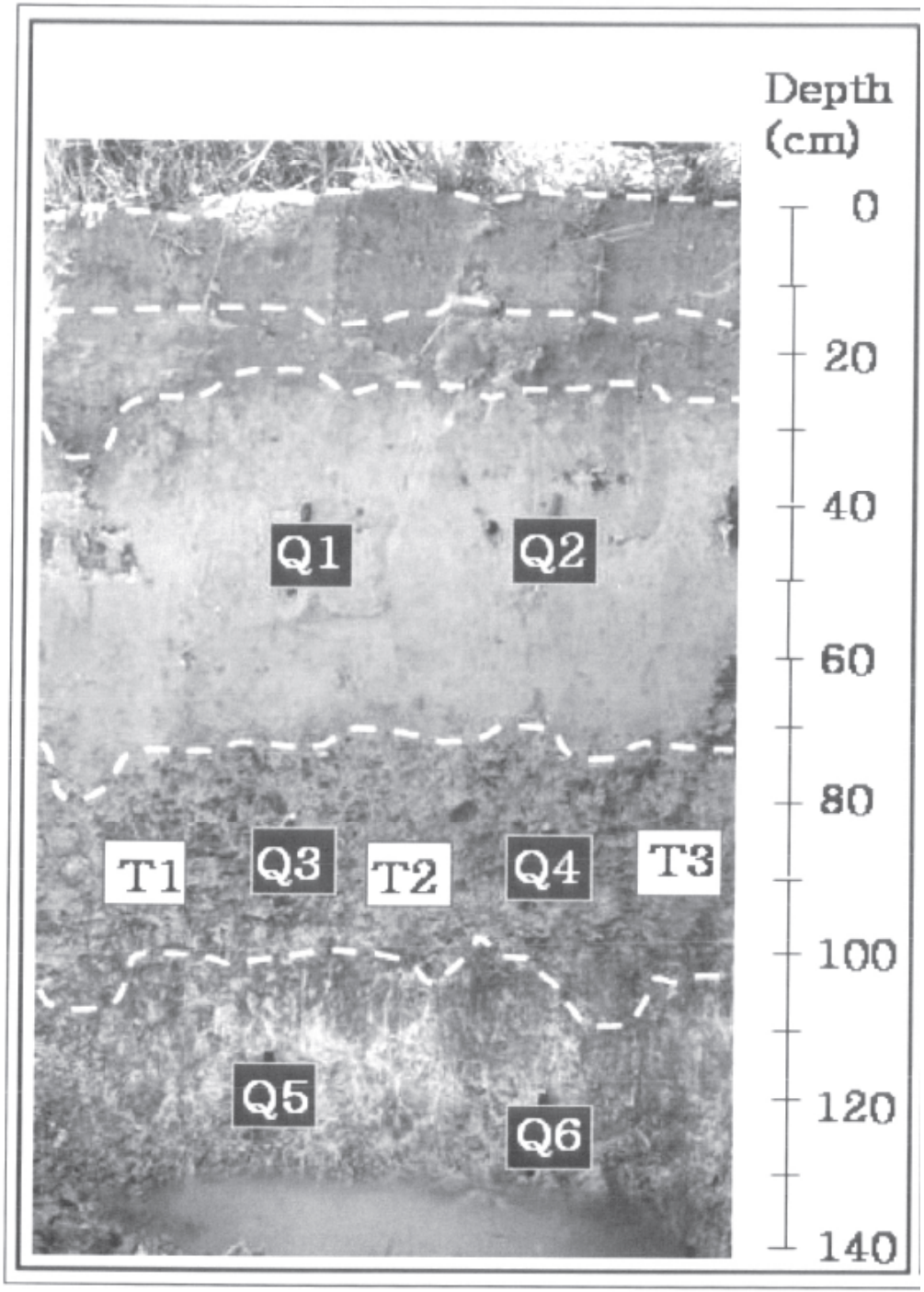


Stratigraphy of the Quaternary sedeiments at Buntarick area

Ages of Tektite and Quaternary sand, Ubonratchathani

Table 1 TL dating results of Quaternary sediments and tektite samples from Buntharik area.

Sample number	Material	Technique	Annual dose (Gy/ka)	Plateau range (°C)	Equivalent dose			TL date (Ka)
					Natural (Gy)	Residual (Gy)	ED (Gy)	
Q1	S	TB	0.64	270-350	26	8.9	16.7	25.9±4.3
Q2	S	TB	0.68	290-340	29	9.6	19.7	28.9±6.3
Q3	S	TB	1.41	250-320	281	33.9	248	175±28
Q4	S	TB	1.69	280-310	193	10.7	182	108±14
Q5	S	TB	2.61	300-330	1,100	85	1,014	388±68
Q6	S	TB	2.29	290-320	862	30	832	363±45
T1	T	TB	6.47	300-340	6,000	0	6,000	927±174
T2	T	TB	6.77	300-350	6,400	0	6,400	945±169
T3	T	TB	7.55	300-350	6,100	0	6,100	808±153

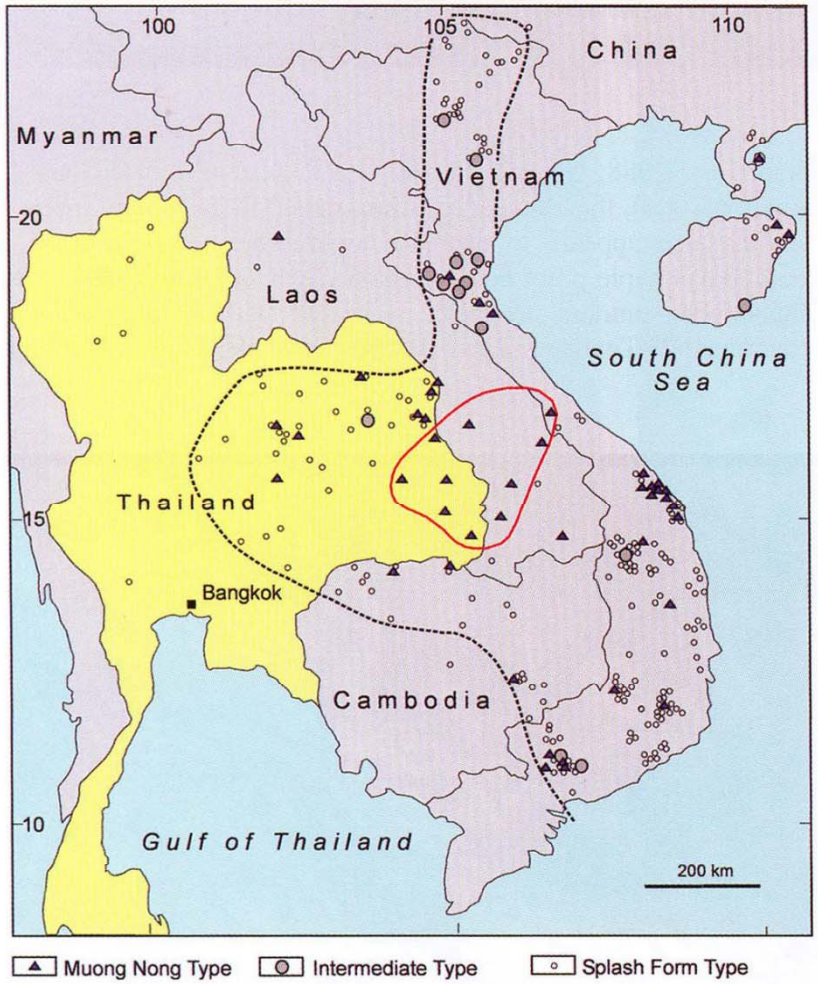


Fig. 21.13. Map showing distribution of tektite types in Thailand and neighbouring countries (from Schnetzler 1992); 90% of tektites are found inside the dashed black line. The solid red line outlines the area in which only layered tektites have been found - the layered-only subfield (from Schnetzler 1992; Fiske *et al.* 1996, 1999). For a more accurate map of the layered-only subfield dimensions, see Fiske *et al.* (1999). The large, blocky, layered tektites are considered 'proximal' ejecta relative to the splashform types; this layered-only region is therefore considered to be relatively close to the source crater location.

Location of Impact crator based on
Be abundance of tektite

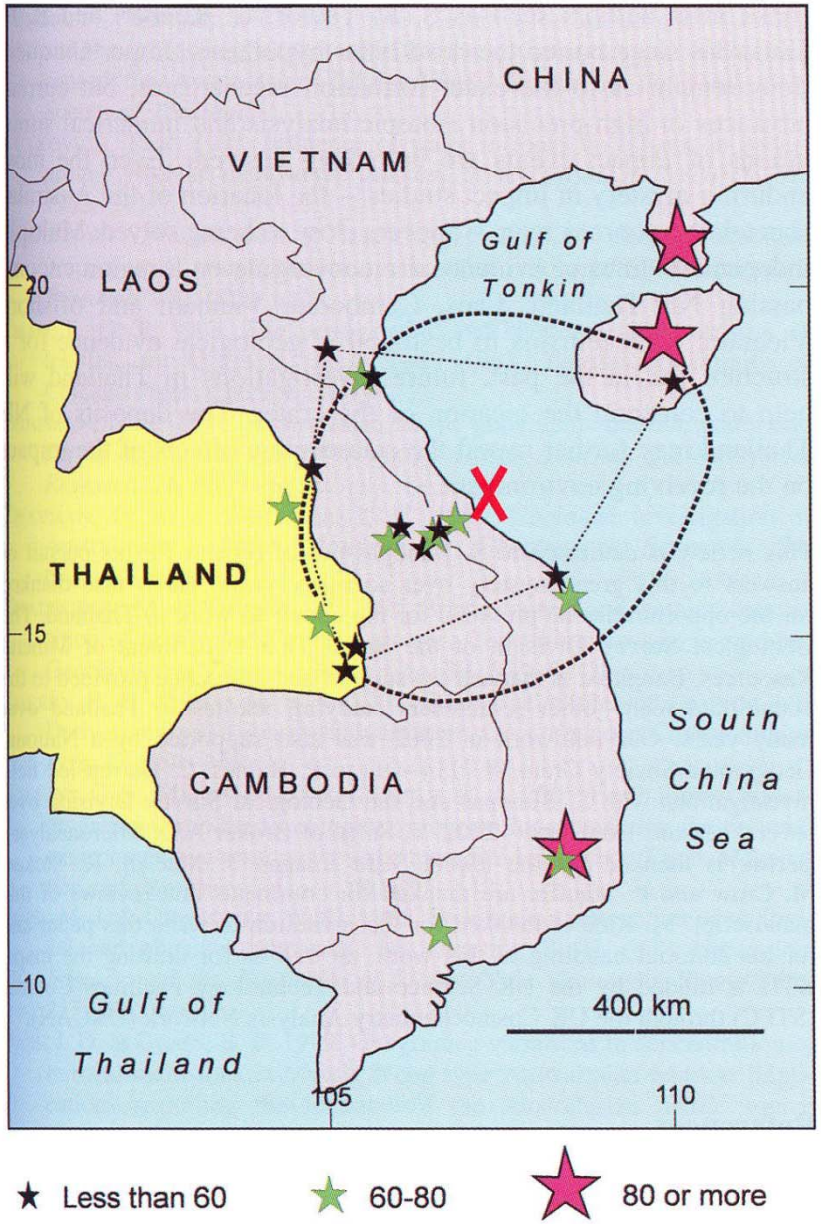
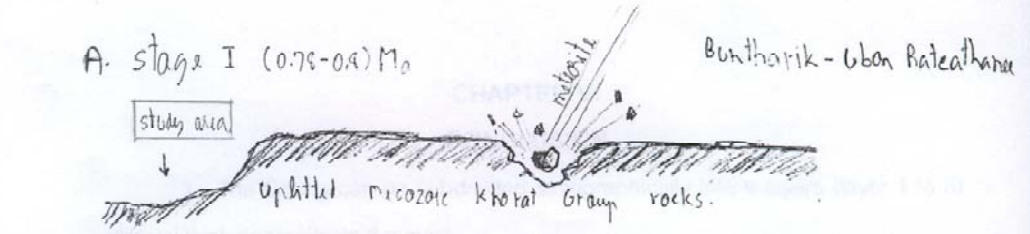
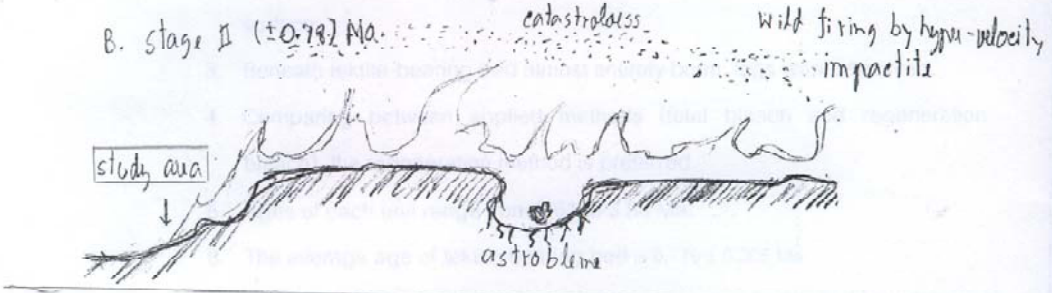
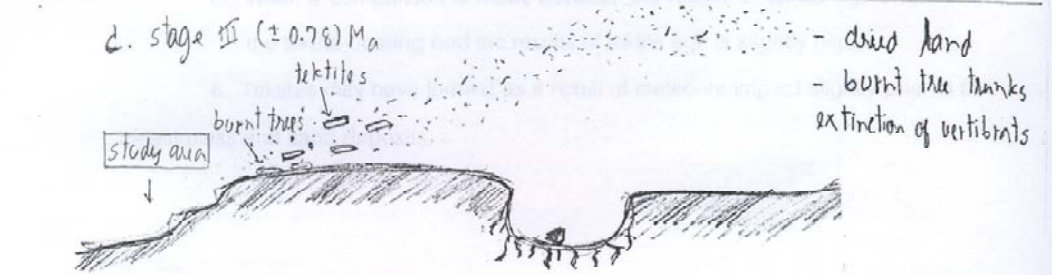


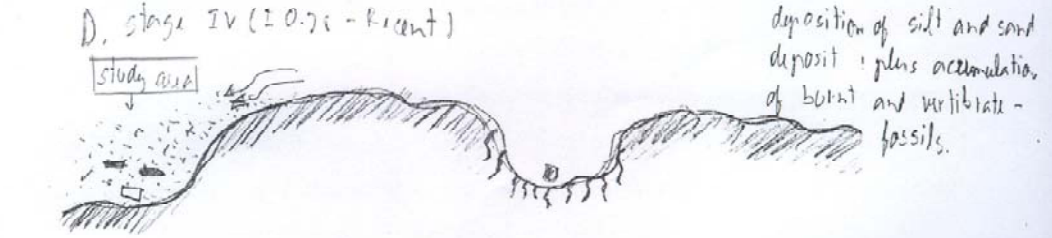
Fig. 21.14. Contoured ^{10}Be abundances in SE Asian tektites. The smooth heavy dashed line separates tektites from higher and lower ^{10}Be contours. The lighter dashed line encloses all tektites with concentrations $<60 \times 10^6$ atoms. The Australasian tektites are believed to have formed within the region bounded by these curves; the red X is the approximate centre of the smooth heavy curve (from Ma *et al.* 2004).

Evolution model of the upper part of the Thachang sandpit









Summary of the effect

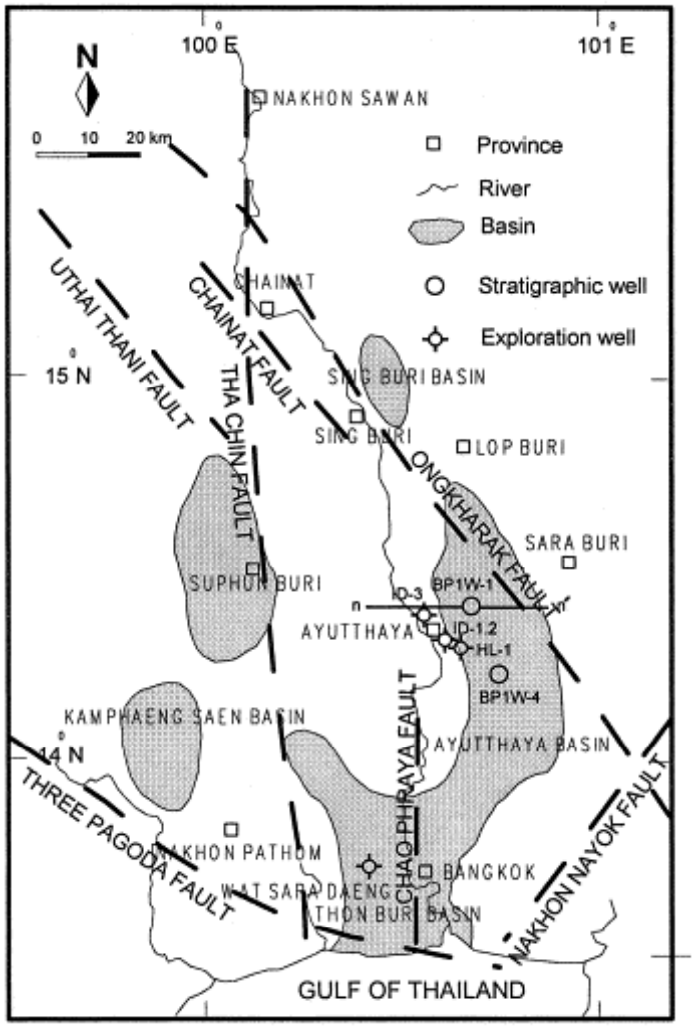
- Catastroloess sediments
- Tektites
- Forest fire and burnt trees

- Extinction of some Miocene animals

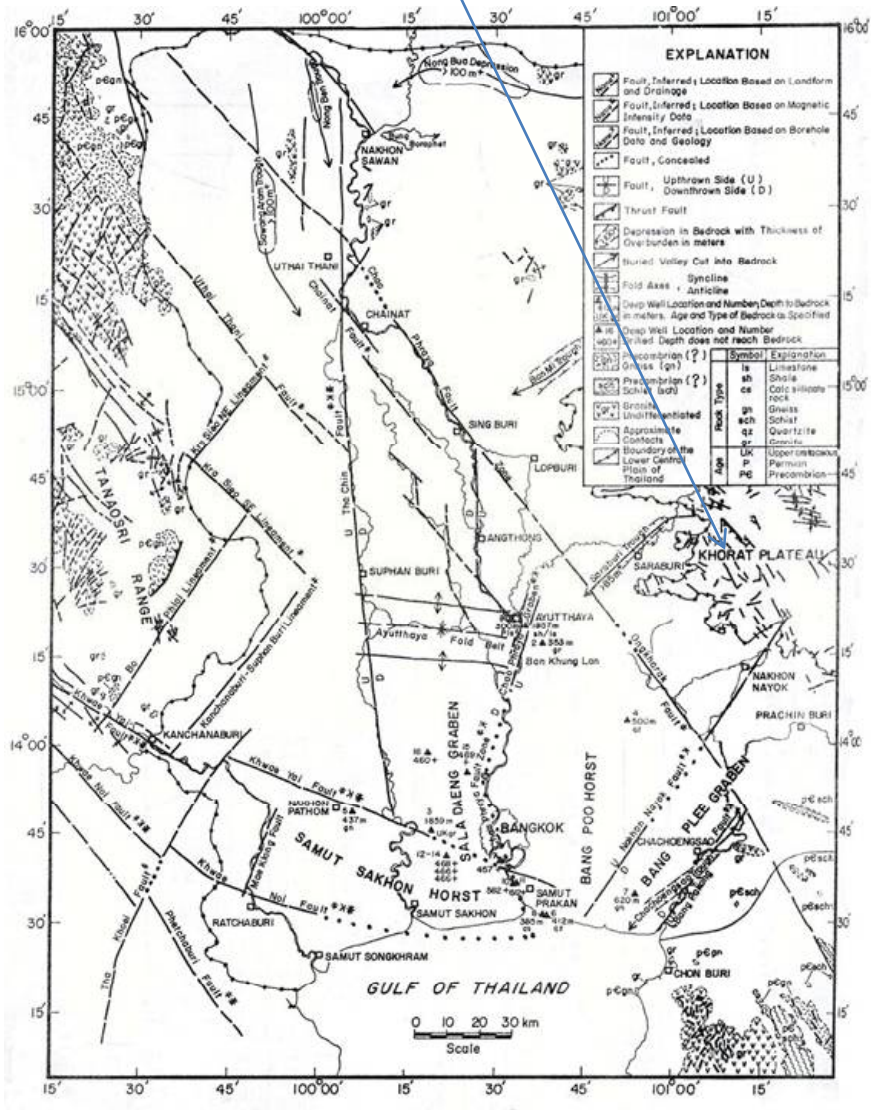
Fish remain

Stegodon molar

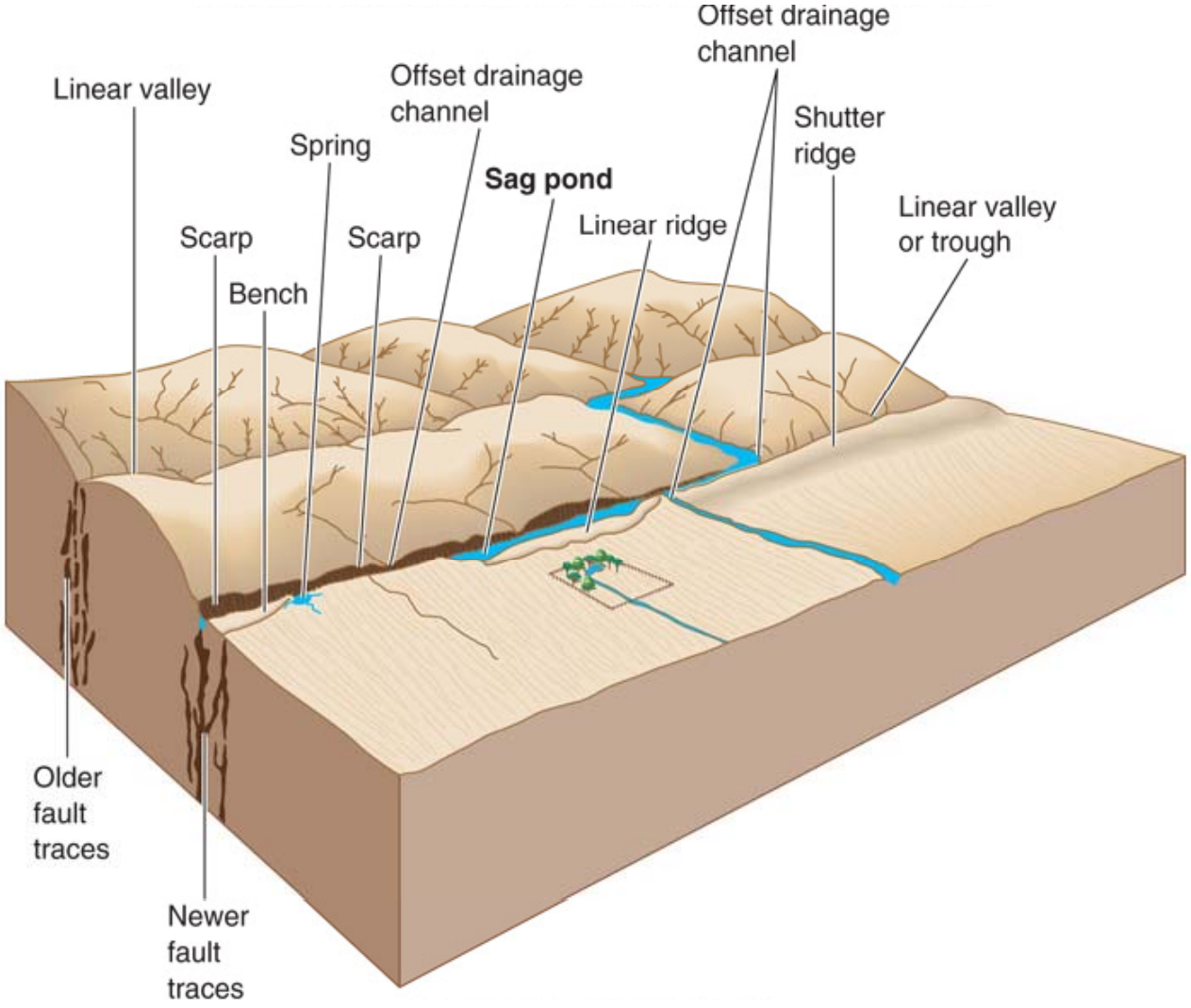
Ongkarak Fault



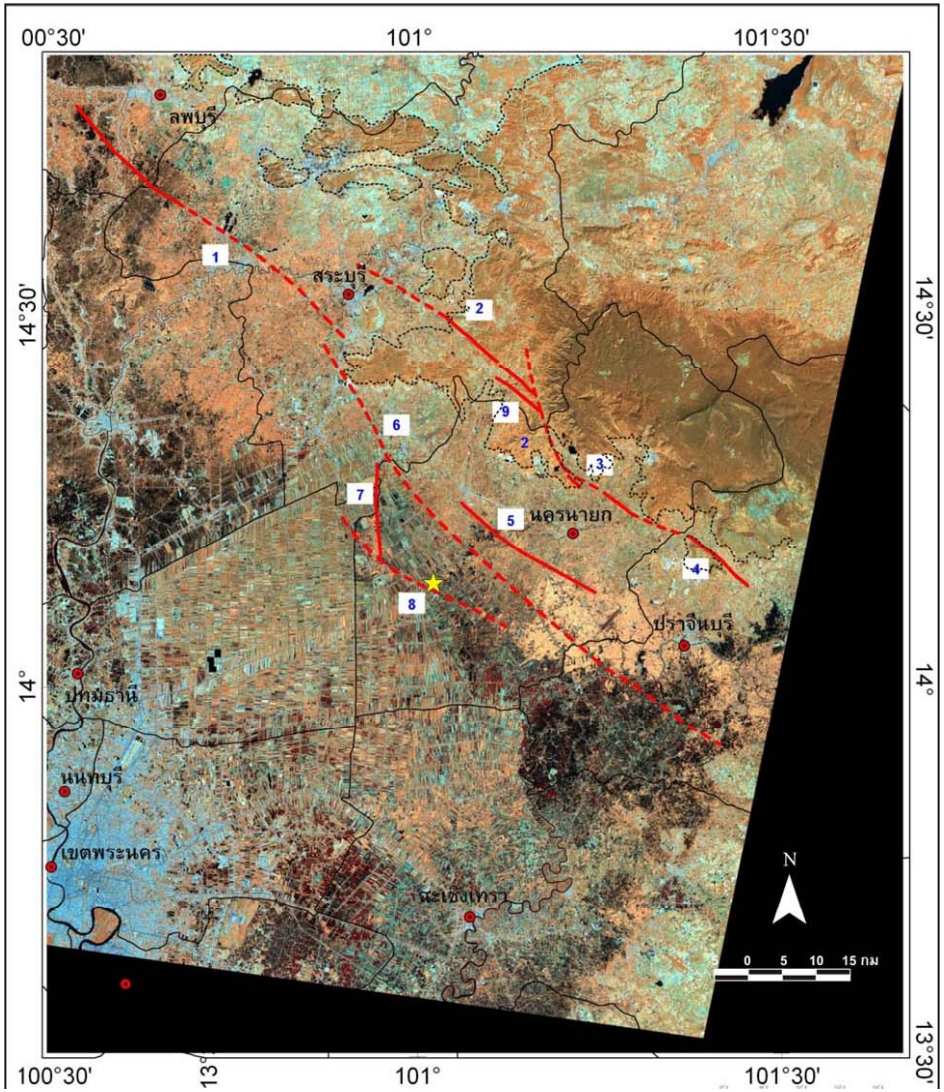
The major NW-trending Ongkharak Fault may have been reactivated in the western edge of the Plateau (Nutalaya and Rao, 1981)



Morphotectonic features along the Ongkarak Fault



Field and Remote sensing result: 7 fault segments were identified



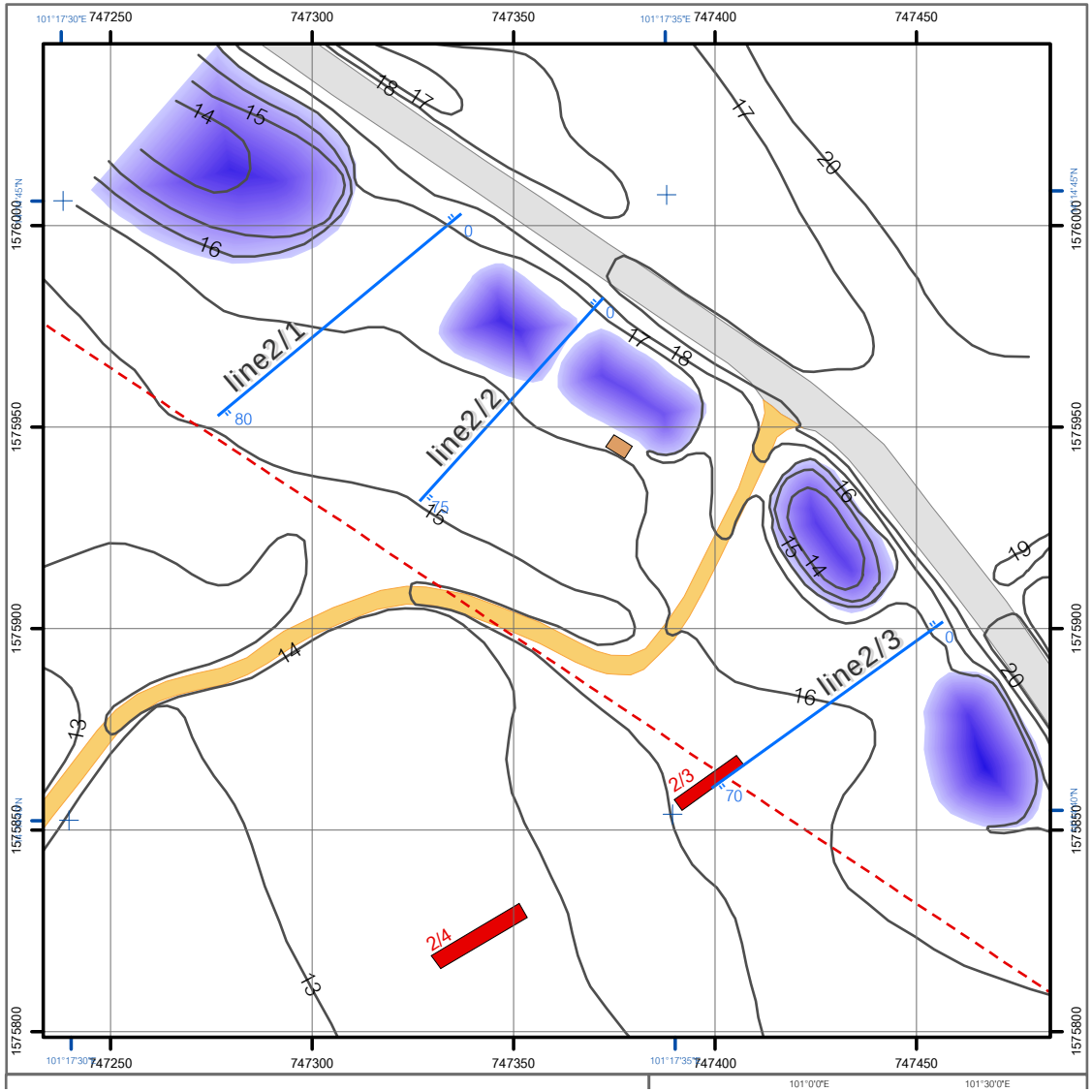
1. Klong Sakae F
2. Ban Na F.

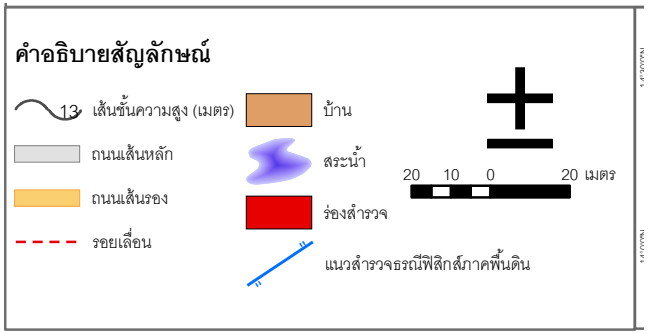
3. Khao karieng F.
4. Nakhon Nayok F.
5. Klong Maenam Nai F.

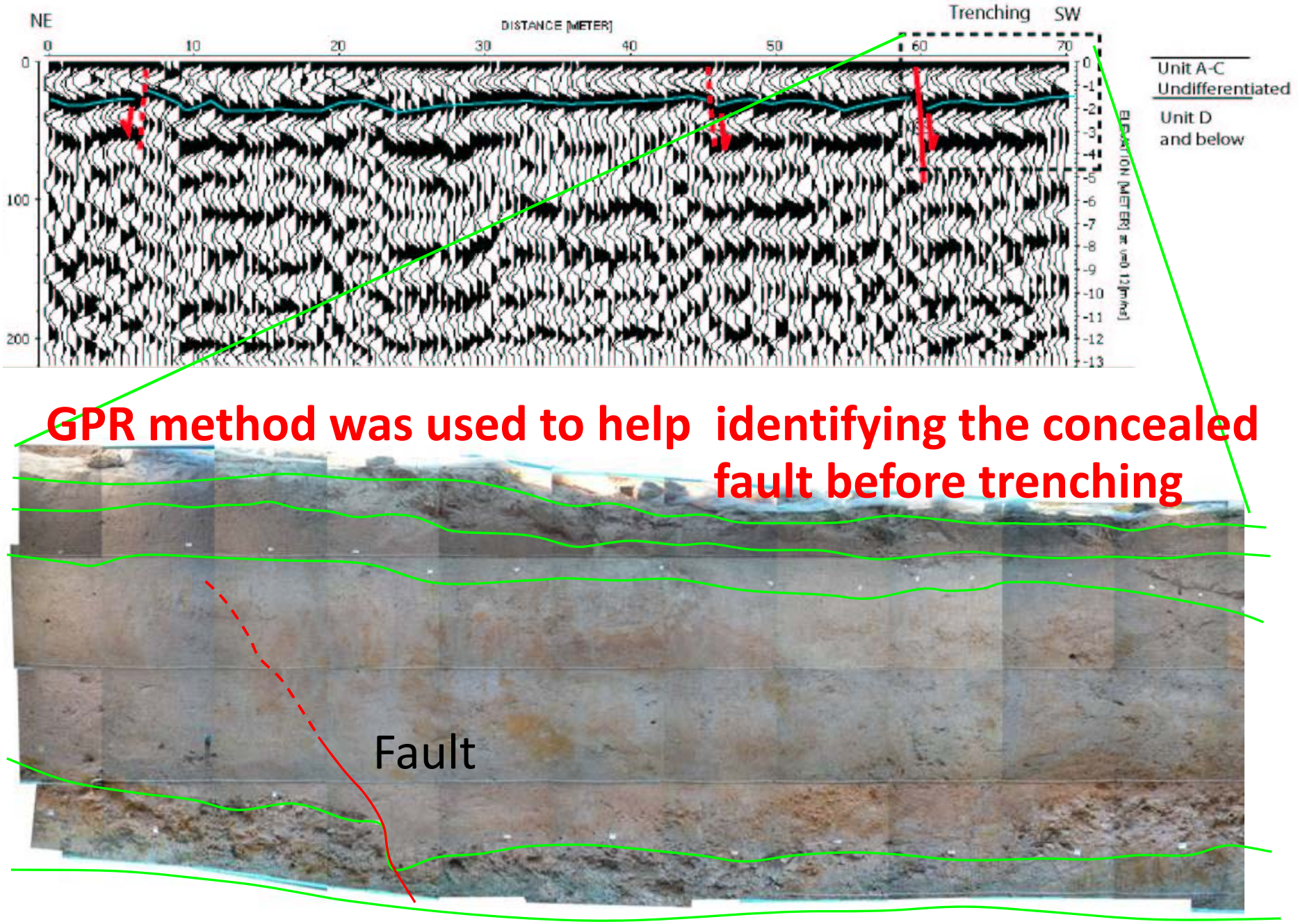
.

6.Ongkarak F.
7. Khao Satont Song F.

Detailed topographic map of Ban Khao Karieng , Amphoe Muang, Nakhon Nayok, showing trench and fault locations






NE
DISTANCE [METER]
0
10
20
30
40
50
60
70
Trenching
SW
0
100
200
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
Unit A-C
Undifferentiated
Unit D
and below
GPR method was used to help identifying the concealed fault before trenching
Fault

Fault was identified at Ban Khao Karieng

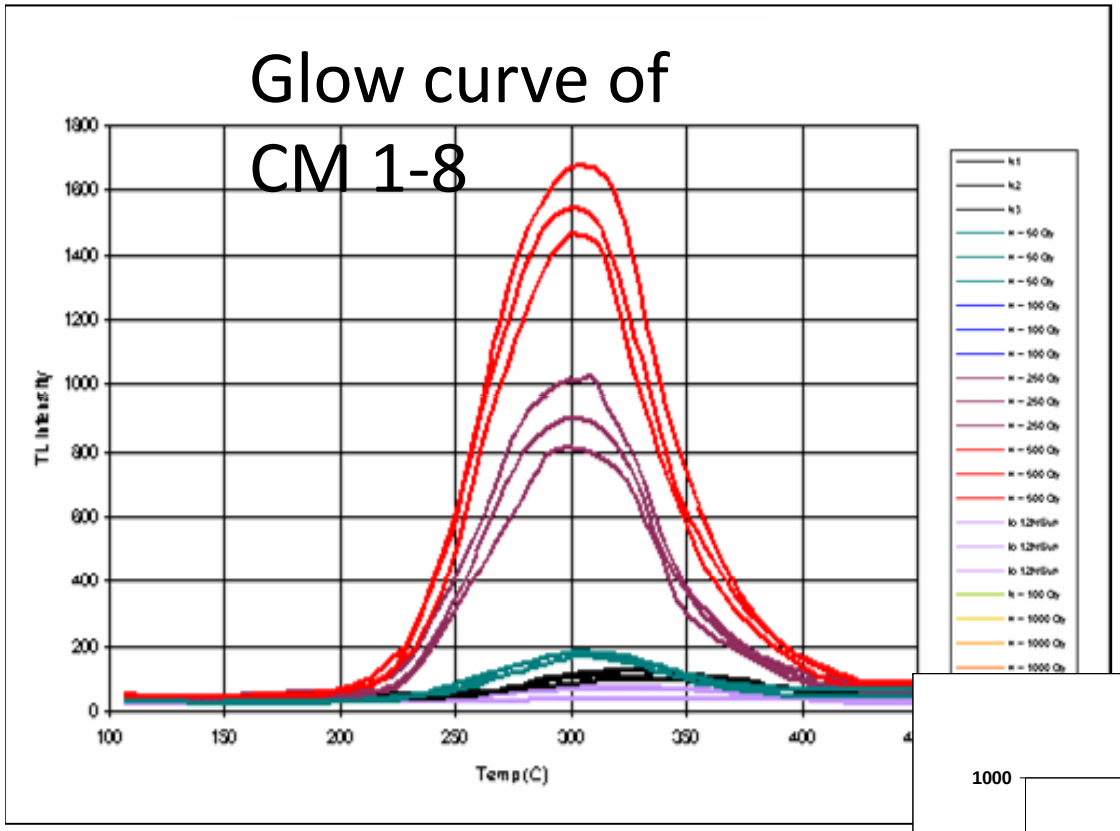
Trench

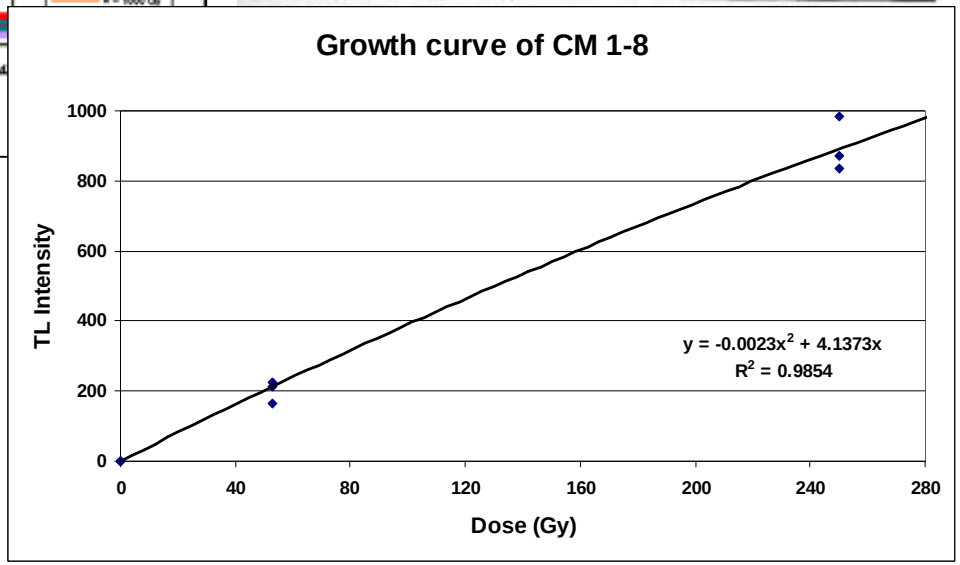
50

เซนติเมตร

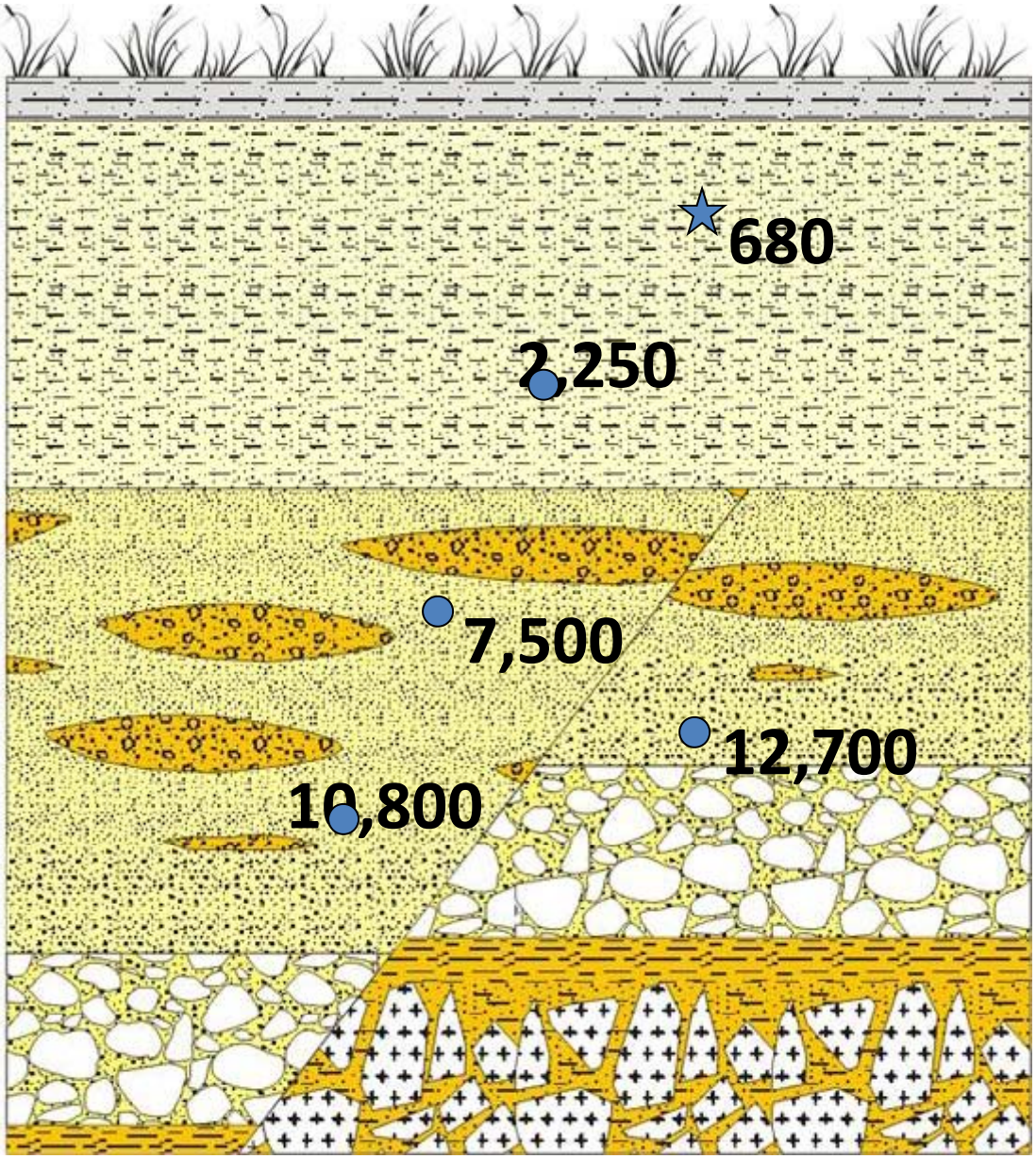
Paleoseismic Trenches were made across some fault segments

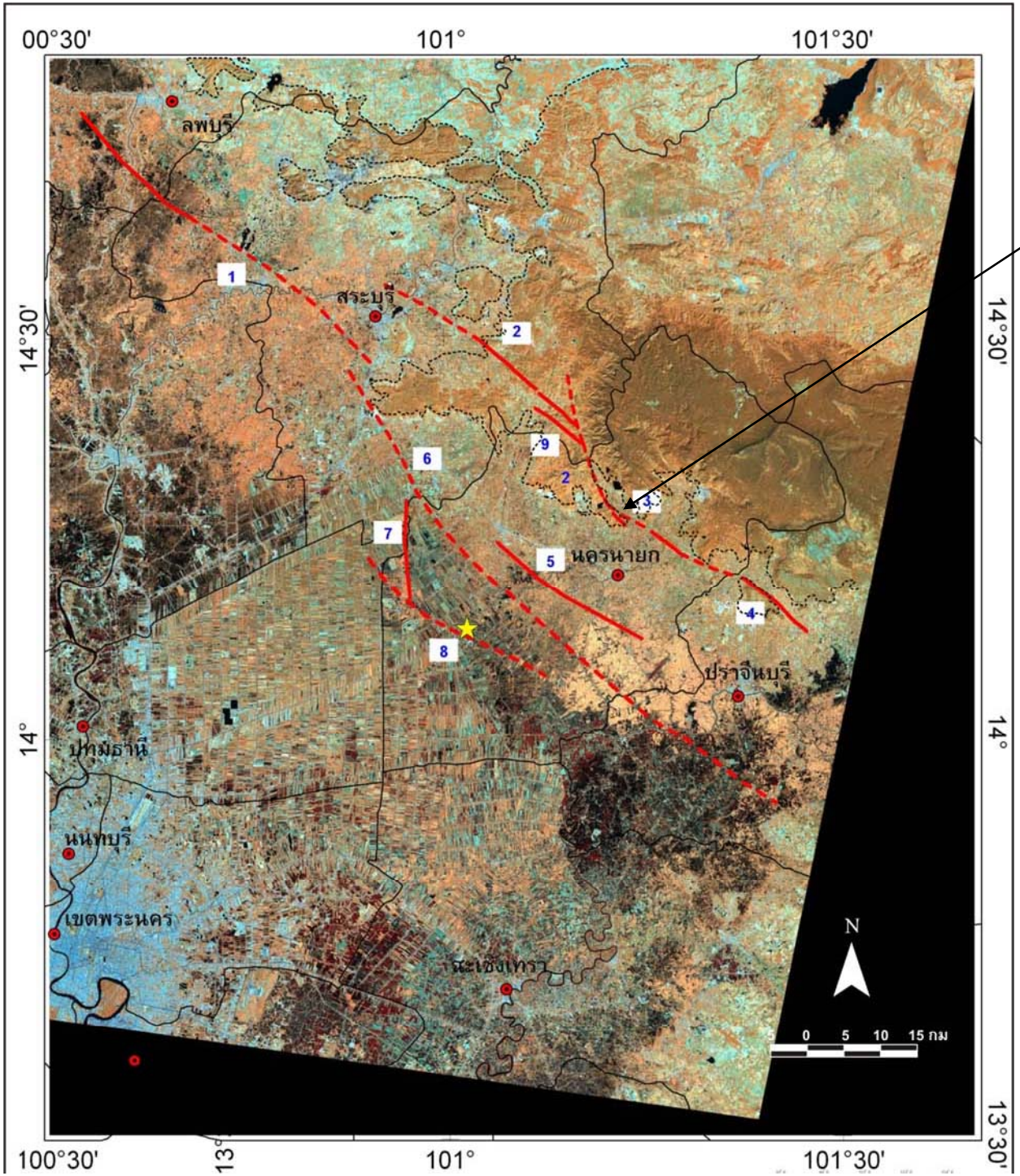
Thermoluminescent Dating of sediments associated with fault





Quaternary stratigraphy of the Ban Khao Chong Karieng trench

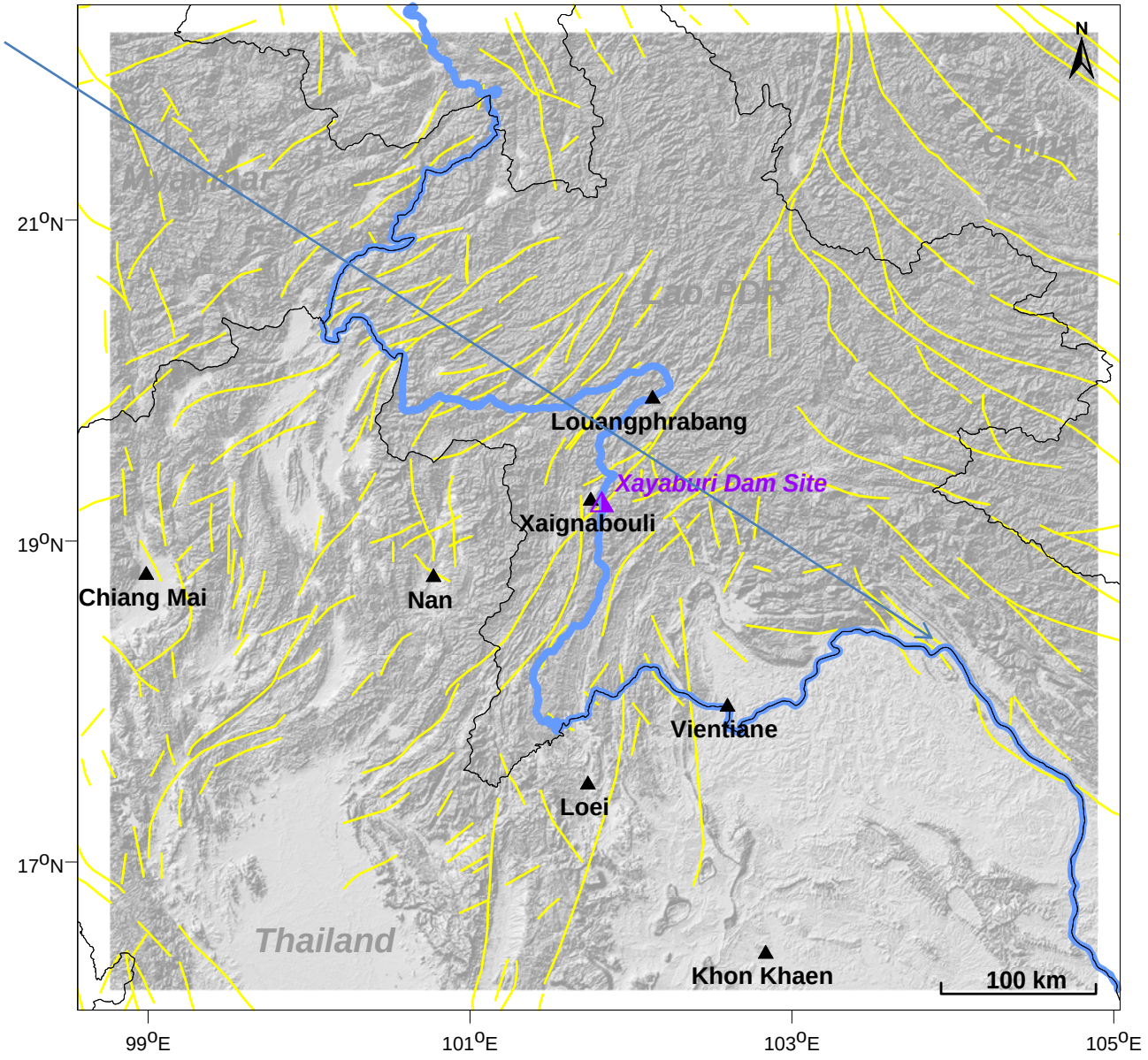




Ban Khao Karieng fault segment

With the maximum paleoearthquake of Mw 6, slip rate of about 0.2 mm/yr, and return period of about 600 yr

Thakhek Fault in Thai-Lao border and at the northern edges of the Plateau, is preliminarily regarded as the active fault if careful investigation will be made in the future



Conclusion

- Khorat Plateau was uplifted during Paleogene (~40 Ma) deformation
- Volcanic Eruption (0.7 - 25 Ma) in southern ESAN
- Uplifting and tilting (<1 Ma) in southern ESAN

causing the main rivers and their river terrace deposition

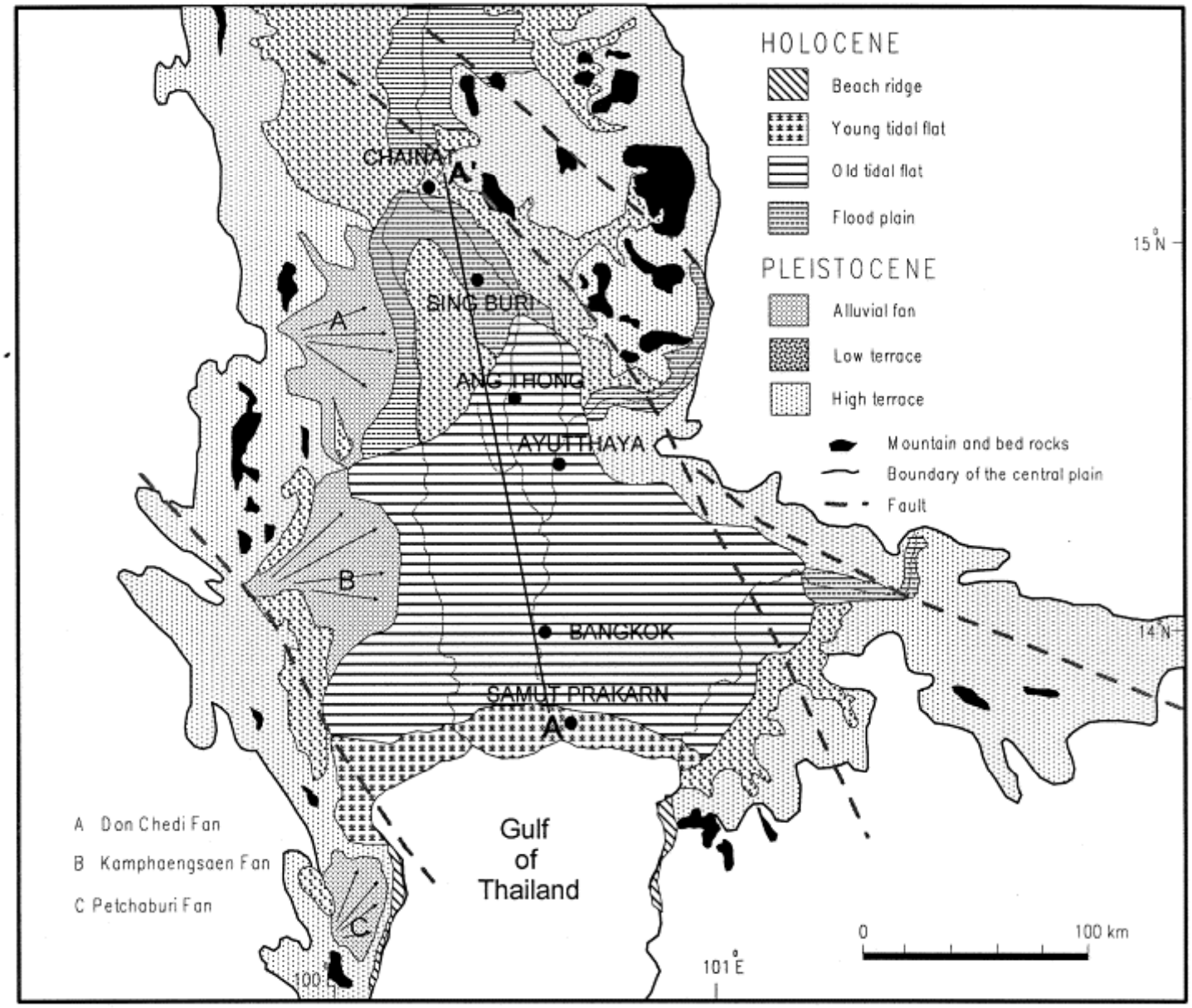
+ Boontharik meteorite impact (0.7-0.8 Ma)

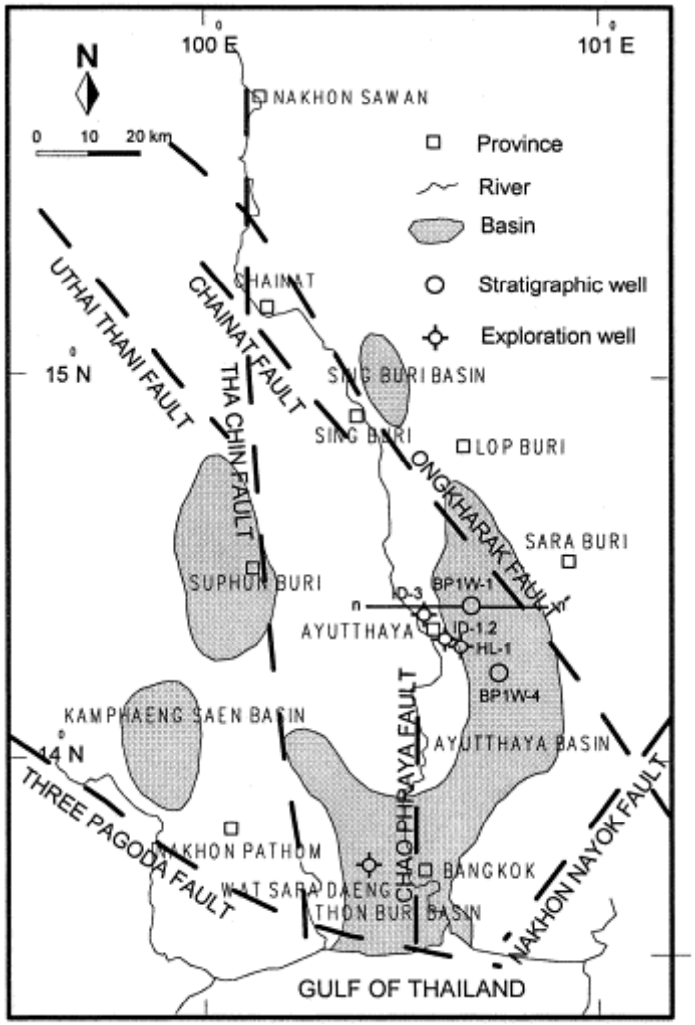
+ Catatroloess causing Climate change and extinction of animals

+ Not only Ongkarak Fault is still active but also some (Thakhek at Thai-Lao border) with the maximum paleoearthquake of Mw ~6

Thank you
for your kind attention

(a)


HOLOCENE
Beach ridge
Young tidal flat
Old tidal flat
Flood plain
PLEISTOCENE
Alluvial fan
Low terrace
High terrace
Mountain and bed rocks
Boundary of the central plain
Fault
CHAINAT
A'
SING BURI
ANG THONG
AYUTTHAYA
BANGKOK
SAMUT PRAKARN
A
B
C
A Don Chedi Fan
B Kamphaengsaen Fan
C Petchaburi Fan
Gulf of Thailand
15°N
14°N
100°E
101°E
0
100 km


N
100 E
101 E
15 N
14 N
0 10 20 km
Province
River
Basin
Stratigraphic well
Exploration well
NAKHON SAWAN
CHAINAT
SING BURI BASIN
SING BURI
LOP BURI
SARA BURI
SUPHAN BURI
AYUTTHAYA
KAMPHAENG SAEN BASIN
AYUTTHAYA BASIN
NAKHON PATHOM
BANGKOK
WAT SARA DAENG
THON BURI BASIN
GULF OF THAILAND
UTHAI THANI FAULT
CHAINAT FAULT
THA CHIN FAULT
ONGKHARAK FAULT
CHAO PHRAYA FAULT
THREE PAGODA FAULT
NAKHON NAYOK FAULT
BP1W-1
O-3
ID-1.2
HL-1
BP1W-4