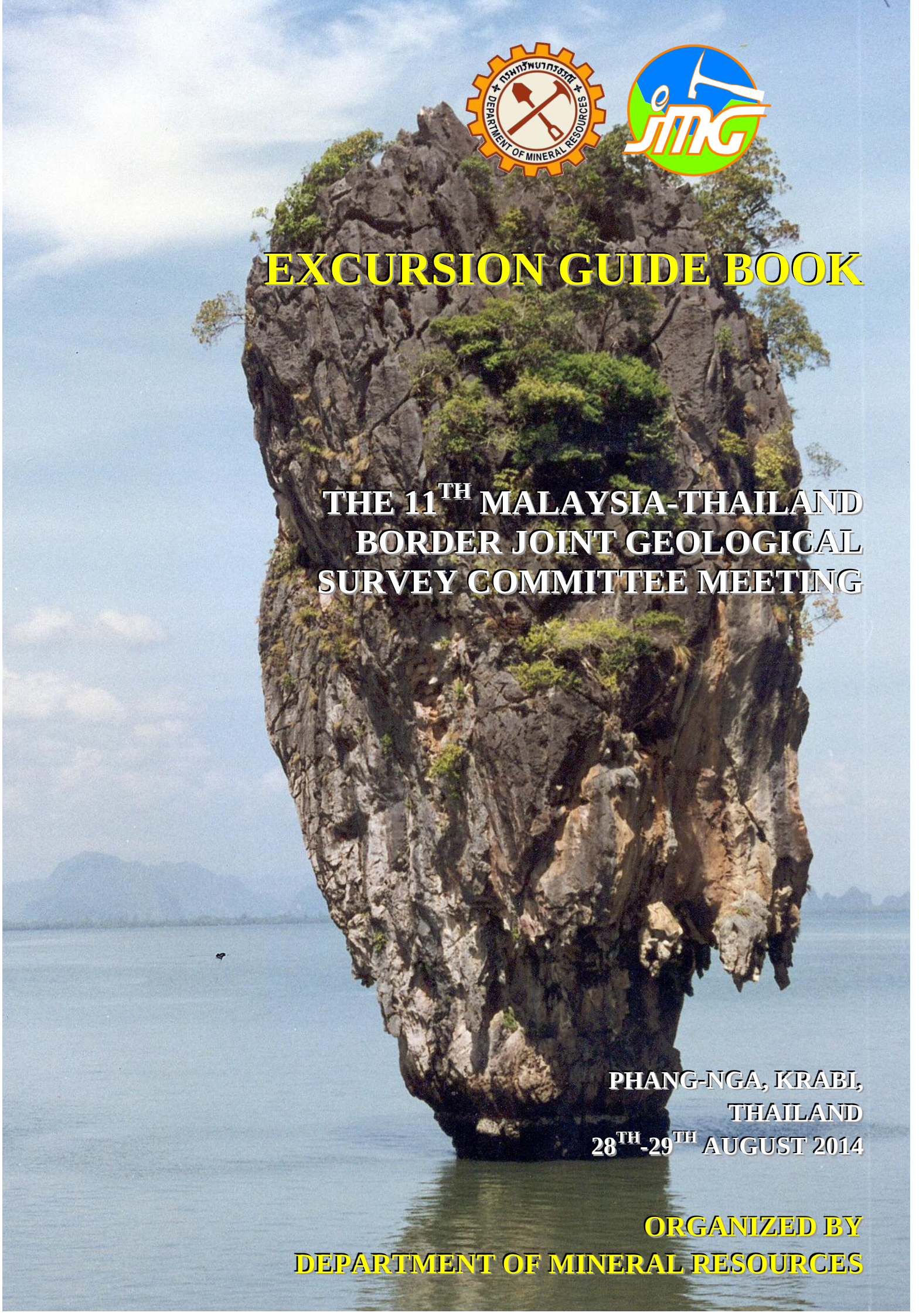


EXCURSION GUIDE BOOK

THE 11TH MALAYSIA-THAILAND BORDER JOINT GEOLOGICAL SURVEY COMMITTEE MEETING

PHANG-NGA, KRABI,
THAILAND
28TH-29TH AUGUST 2014

ORGANIZED BY
DEPARTMENT OF MINERAL RESOURCES

Preface

This Manuscript is prepared for a two days field check programme in order to fulfill the 11th Malaysia-Thailand Border Joint Geological Survey Committee Meeting held in Phang-nga Province, Thailand from 25th – 30th August 2014. The main aims of the project are to minimize the geological discontinuities along the Malaysia-Thailand border and to update the geological information of the two countries in various scales.

Details on Geology, Stratigraphic correlation and Geohazard of the Transect area along the Malaysia-Thailand border have been presented and discussed during the meeting held at Kantary Beach Khao Lak Hotel. Correlation of rock units, stratigraphy and fossil assemblages of the northern part of the Malaysian side and southern part of the Thai side can be made at some levels.

Field check routes show a large variety of geological evidences on the Thai side including typical rock units, fossils, geotourism and mineral deposits at the Ko Yao Noi and Takuapa - Phang-nga and Ao Luk area. The first place is known as the significant areas of the type locality of the Early Permian succession and beautiful karst topography limestone. Takuapa - Phang-nga places are localities for various case studies of mineral deposits, hot spring and huge of beautiful Permian karst topography whereas the third place is known as the area for abundant fossils assemblages in the Paleozoic rocks.

Finally, the organizers of this joint field trip do hope that this manuscript will benefit not only for all participants of this trip but also for those who are interested in geology, mineral deposits, geohazard and geopark managements particularly in this region.

Suvapak Imsamut
Warunee Yatakum
Chamlong Kedsatit
and
Thai Working Group

August 2014

Contents

1) PREFACE……..…… 1

2) PHANG NGA PROVINCE……..…….. 3

3) EXCURSION PROGRAMME……..……. 5

4) GEOLOGY AND STOPS OF PHANG-NGA-KRABI AREAS..…... 6

5) GEOLOGY OF THE KO YAO NOI …….……..... 10

6) DESCRIPTIVE ITINERARY…… 13

STOP 1: Laem Sai, Ko Yao Noi, Phang-nga Province……..…… 16

STOP 2: Ao Mueng, Ko Yao Noi, Phang-nga Province…… 18

STOP 3: Ko Kudu Yai, Ko Yao Noi, Phang-nga Province……..…….. 20

STOP 4: R.A.T. Trading & mining (Takuapa) Co., Ltd., Takuapa District, Phang-nga Province…… 22

STOP 5: Ban Bon Ton, abandon Tin deposit,Phang-nga Province……. 25

STOP 6: Hot Spring, Ban Plai Phu, Ka Pong District, Phang-nga Province……..... 28

STOP 7: Somdet Phra Sri Nakarin Park, Mueang District, Phang-nga Province…. 30

STOP 8: Geomorphology of the active fault in Bang Riang Temple view point, Thap Put District, Phang-nga Province……..… 32

STOP 9: Brachiopod site of the Ao Nam Area, Krabi Province……... 37

7) EXCERPT PAPERS…… 42

Phang-nga Province

http://en.wikipedia.org/wiki/Phang_Nga_Province
http://www.know-phangnga.com/geography.php

Phang- nga is one of the southern provinces of Thailand, on the shore to the Andaman Sea. Neighboring provinces are (from north clockwise) Ranong, Surat Thani and Krabi Province. To the south is the Phuket province. Phang-nga is a city has a population of 259,420 (2013), and an area of 4,170.895 square kilometers. The city's population density is 62.19 inhabitants per km².. This City is subdivided into 8 districts which are further subdivided into 48 communes and 314 villages.

Geography

Phang-nga is on the southwest coast of Thailand on the Malay Peninsula. The province's capital town is 788km drive south of Bangkok. It is 930km north of the equator (8.2 degrees latitude).

Phang -nga lies by the Andaman Sea which is part of the Indian Ocean. The province includes islands to the west and southeast of the province. The province mainland is 135km long at its longest point and 52km wide at the widest point. The east of the province is high mountainous terrain that slopes down towards the western coastline.

The province's topography is mostly jungle covered mountains which cover more than 55% of the land. The highlands are granite rock. The west and southwest of the province have some low plains which are suitable for agriculture although the soils can be rather sandy. These areas have rubber plantations, palm oil, coconut groves and other agriculture.

The province's 240-kilometer winding coastline is almost entirely sandy beaches or coastal mangroves. The best beaches are all along the western coastline where the rainy season waves pound into the coast forming beautiful sandy beaches.

Phang- nga province includes 105 islands. These include the spectacular Similan and Surin islands to the west which are world renowned scuba diving and snorkelling locations. There are several major rivers that flow from the mountains either into the Andaman Sea or into Phang-nga Bay. These include the Nga River, Sai Buri River, and Yaring River.

History

During the reign of King Rama II, nearby areas (including Thalang, now known as Phuket) were occupied by the Burmese and so many people fled to Kraphu-nga. In 1824, Siamese troops defeated the Burmese and the invaders were expelled. King Rama III renamed the area Phang-nga and in 1933 the town was expanded to be a province.

On the morning of December 26, 2004 Phang-nga Bay was devastated by a Tsunami disaster and thousands of people lost their lives.

Local Culture

Phang-nga is a melting pot of Buddhists, Thai-Chinese, Muslims and even sea gypsies. The majority of the population in the rural areas is Muslim. Phang -nga however, does not suffer from any religious tension and the folk live in peace and harmony. Outside of the provincial town, the rural folk speak with a thick Southern dialect which is difficult for even other Thais to understand. With this kind of mixture, Phang -nga is always celebrating something be it part of Thai Buddhist, Thai-Chinese or Thai-Islamic tradition.

Situated on the small island of Ko Surin is a community of Morgan Sea Gypsies who still live their traditional life as seafaring people. These sea gypsies speak Yawi dialect and are more very friendly. However, just like the long-necked Karen in Mae Hong Son, some folk complain that their village resembles a bit like a human zoo with hoards of tourists walking around gawking at the villagers.

Attraction places

Most attractions in Phang-nga are major excursion destinations from Phuket. The following are among the best known such as Ao Phang-nga (Phang-nga Bay), Khao Phingkan, Ko Tapu (James Bond Island), Ko Panyi, Khao Lak, Similan Islands, Surin Islands. Now Phang-nga is popular for eco-tourism. There are many tour operators organizing a large variety of activities in this area, such as sea canoeing, rafting, elephant trekking, jungle trekking, diving, etc.

Excursion Programme

The 11th Malaysia-Thailand Border Joint Geological Survey Committee Meeting

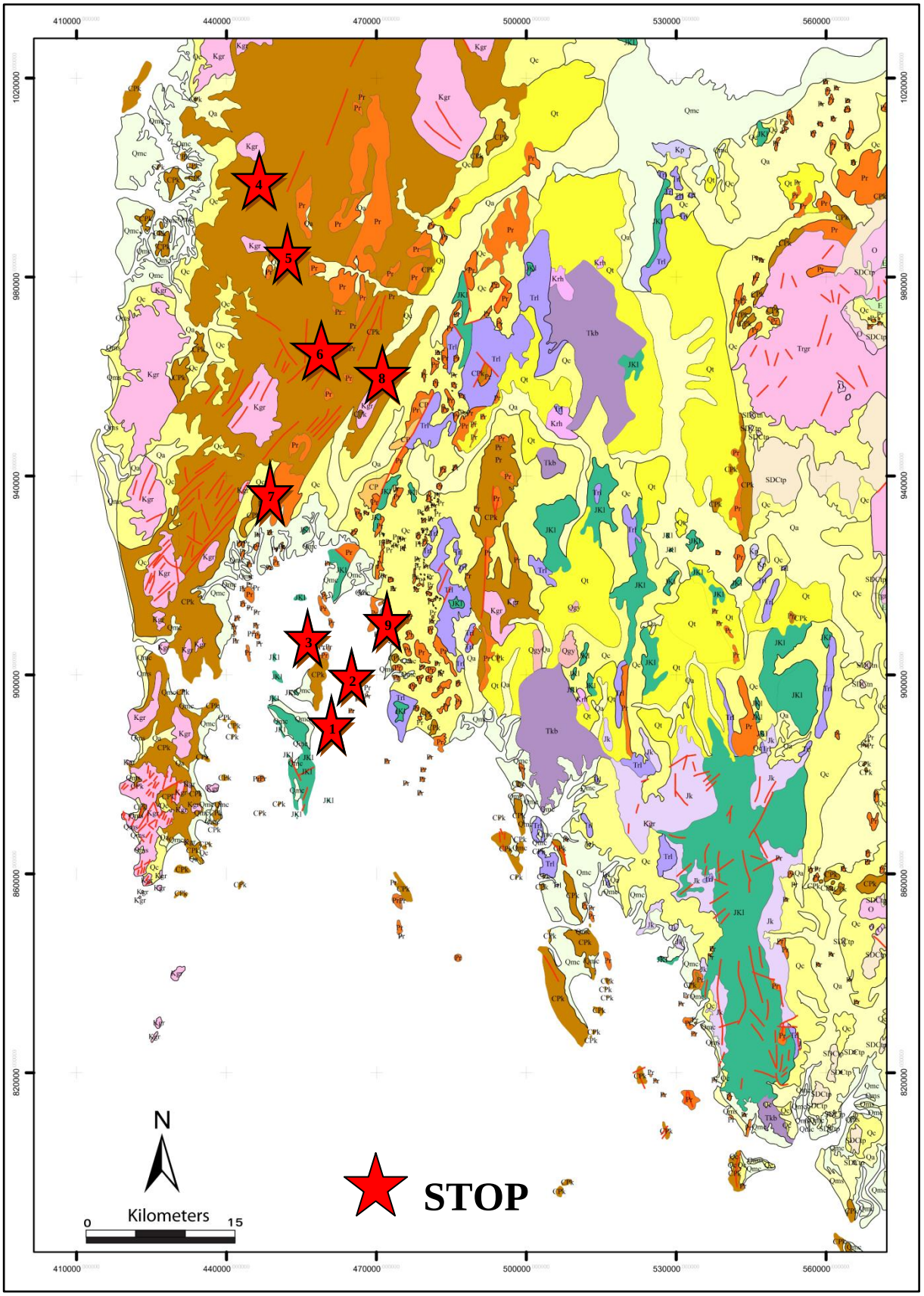
Thursday 28th August 2014

07:15	Leave the Kantary Beach, Khao Lak Hotel for Bang Rong Port, Phuket
09:30	Leave Bang Rong Port for Ko Yao Noi by Speedboat
10:00-10:30	Visit the Pearl Farm in Ko Naka/Ko Rang Yai (Depending on weathered condition)
11:00-11:50	**STOP 1**: **Laem Sai,** Ko Yao Noi, Phang-nga Province Fossiliferous tuffaceous clastic rocks in Early Permian sequence
12:00-13:00	Lunch in Laem Sai restaurant
13:00-14:00	Observe Ko Yao Noi town by local minibus and speedboat
14:30-15:15	**STOP 2**: **Ao Mueng,** Ko Yao Noi, Phang-nga Province Limestone with chert nodule in Middle Permian sequence
15:30-16:30	**STOP 3: Ko Kudu Yai,** Ko Yao Noi, Phang-nga Province Beautiful Karst morphology in north of the Ko Yao Noi Island
16:30-17:00	Leave Ko Yao Noi for Bang Rong Port, Phuket by speedboat
19:00-20:00	Dinner at Krua Muslim Restaurant, Khao Lak, Phang-nga Province
21:00	Overnight at Kantary Beach Khao Lak Hotel

Friday 29th August 2014

08:00	Checkout at Kantary Beach Khao Lak Hotel for Takupa District
08:30-09.45	**STOP 4: R.A.T. Trading & mining (Takuapa) Co., Ltd.,** Takuapa District, Phang-nga Province Mineral processing of the heavy minerals
10.00-10.45	**STOP 5: Ban Bon Ton Tin deposit,** Phang-nga Province Tin- deposits in granite and pegmatite stock works
11.15-11.45	**STOP 6: Hot Spring, Ban Plai Phu,** Ka Pong District, Phang-nga Province Attraction place for tourism in Ka Pong District
12.00-13.30	Lunch in Phu Nga Hotel, Mueang Phang-nga and Dzuhur prayer
13.30-14.00	**STOP 7: Somdet Phra Sri Nakarin Park,** Mueang District, Phang-nga Province Stone park of the Permian limestone sequence in Phang-nga Province
14.45-15.45	**STOP 8**: **Bang Riang Temple view point**,Thap Put District, Phang-nga Province Morphology of the active Khlong Marui fault
16.30-17.00	**STOP 9: Brachiopod site of the Ao Nam Area**, Krabi Province Abundant fossiliferous beds
18.00	Check in at Crystal Hotel, Krabi Province
19:00-21:00	Farewell dinner at Rebeab's Kitchen inter-buffet (Halal food) in Krabi Province Overnight at Crystal Hotel END OF EXCURSION

Geology and stops of the Phang-nga - Krabi area



Geology of the Phang-nga Province

Geology of the Phang -nga Province can be divided into 3 main groups including igneous rocks, sedimentary rocks and unconsolidated sediment. The area is mainly sedimentary rocks which are about 50% of total area. Limestone mountain range is distributed in the southeast of the province and granite is in the west.

Stratigraphy

1. Kaeng Krachan Group: consists of grey, greenish grey and blackish grey pebbly mudstone, pebbly sandstone, mudstone and sandstone. The unit was deposited in the accumulation of marine sediment in the Early Permian Period and is conformable to the overlying Ratburi Group. In Phang-nga area, the Group can be divided into 4 Formations in ascending order to

Laem Mai Pai Formation is thin- bedded sandstone and mudstone in the lower part of the sequence. Bedding consists mostly of wavy and parallel type. Bioturbation (Burrows) are common in this part Sandstone decreases in proportion upward and changes to laminated mudstone in the upper part of the sequence. There are occasional slumped beds and rare dropstones.

Argillite of the Kaeng Krachan Group

Ko He Formation: Pebbly rocks are typical of the Kaeng Krachan Group. It overlies conformably the Laem Mai Phai Formation, and is characterized by an over 125 meters thick sequence of mainly pebbly rocks or diamictite with subordinate, intercalated mudstone and sandstone. It is poorly sorted, with clasts generally 5-30%, and a matrix consisting of silty mud to muddy sand. Clasts are mostly smaller than 2 cm, and consist mainly of quartzite, quartz, sandstone, limestone, marble, granite and gneiss.

Khao Phra Formation: consists of interbedded grey mudstone and pebbly mudstone that overlaid by interbedded mudstone and sandstone with cross bedding particularly in sandstone beds. The top most of this formation comprises calcareous mudstone with abundant fossil of bryozoans.

Khao Chao Formation is divided into 3 parts; the lower part is well-sorted, subangular to well rounded, thick-bedded quartz arenite to arkose, occasionally associated with tuffaceous sandstone and rhyolitic tuff. The middle part is grey, thin-bedded shale, siltstone and mudstone overlain by well-sorted, fine-to medium-grained sandstone with thin shell-bed. The upper part consists of intercalated mudstone, shale, thin-bedded sandstone and limestone.

.

2. The Ratburi Group: lies conformably on the Kaeng Krachan Group. The Permian limestone sequence in the Thai peninsula has long been mapped as a single unit as the Ratburi Group without division into constituent formations and a type section was not proposed. In most areas, this group is mostly massive to bedded carbonates (mainly limestone with occasionally chert nodules and often recrystallized and locally dolomitized), several hundred meters thick yielding foraminifers, corals, brachiopods, bryozoans and crinoids and with minor sandstone and shale intercalations

3. The Lam Thap Formation:

The formation is classified in Thung Yai Group. It is divided into alternating lithofacies; predominantly arkosic sandstone, and sandstone, siltstone and mudstone. In some areas, the formation is made up almost entirely thick-bedded arkosic sandstone. Elsewhere it is siltstone and mudstone interbedded with sandstone and conglomeratic sandstone with common fining-thinning-upwards sequences with planar and hummocky cross-beddings.

Sandstone in the Laem Thap Formation

4. Quaternary: Classification of the Quaternary deposit in Thailand largely depends on the relationship between landforms and chronological evidence. The Pleistocene deposits are mainly found to be related to changing river courses, alluvial and braided systems and the degree of weathering of the base rock. Holocene deposits were much influenced by changes in climate conditions and sea level. The Andaman Sea coast, the deposits are considered to be product of the Holocene marine transgression and regression, and to have formed in both tide- and wave-dominated environments. The quaternary deposits in Andaman Sea can be classified as terrace, alluvial, intertidal mangrove and beach sand deposits.

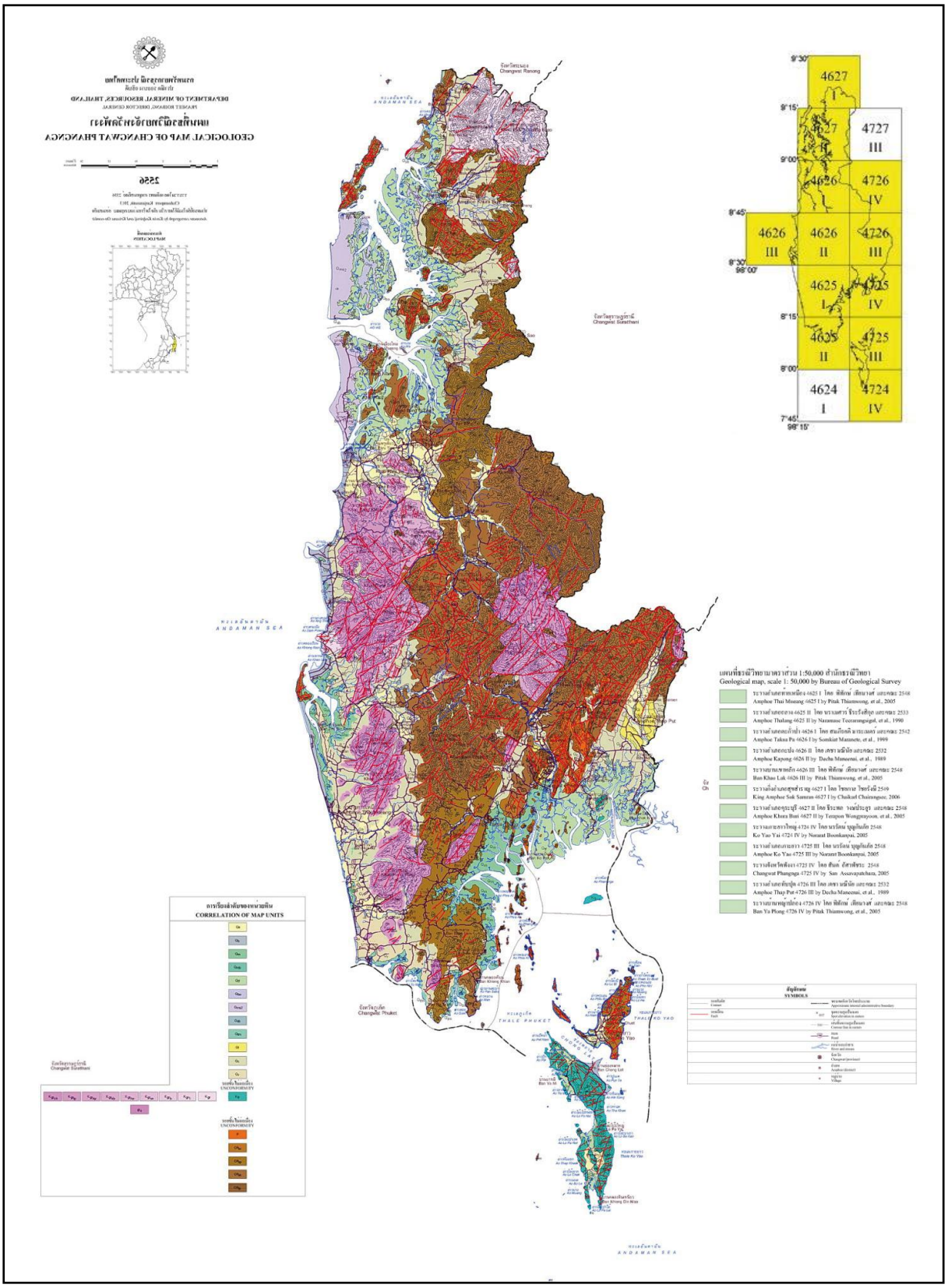
Igneous Rocks

In Phang nga province, Granite is characterized by batholiths, plutons, stocks, pegmatites and units representing different granite types which lie in late Cretaceous. In most places the rocks are porphyritic-qaurtz-biotite granite, leucocratic granite and biotite granite. They are light grey, light pink and greyish brown, coarse-grained feldsparthic granite. In some other places, the rocks are porphyritic-tourmaline-muscovite granite which is fine- to coarse-grained porphyritic granite. Tourmaline are found in both scattered in the rock and assembly. In addition, there are equigranular, fine-grained biotite granite and light, fine- to medium-grained leucocratic granite with tourmaline. Leucocratic granite is mainly composed of feldspar and quartz with rare muscovite, cassiterite and opaque minerals.

Granite in Phang-nga Province

Structural Geology

The main fault sets as Phang-nga- Khlong Ra, Lam Ru-Phru Khang Khao, Phai Mo-Thung Ma Phrao, Bang Khram faults. Khlong Marui-Khlong Kaek fault is the major fault which is northeast-southwest trending. As a result of the major fault movement, there are lots of fractures, joints and minor faults which are parallel or sub-parallel to the major faults. The structures of rocks around the fault zone including granite mountain range, limestone and sedimentary mountain in Khao Nang Hong area were deformed. Folds in the area vary in size from microscopic folds to wider folds. Overturn and recumbent folds are normally presented in North-South and Northeast-Southwest trending, respectively. Fractures and joints are commonly presented in igneous, metasedimentary rocks in various direction. They can be found especially in fault zone. The main trend is northeast-southwest, northwest-southeast, east-west and north-west directions.



Geological Map of the Phang-nga Province

Geology of Ko Yao Noi

Stratigraphy

1. **Kaeng Krachan Group**; Ko Yao Noi and vicinity islands are mostly composed of rock belongs to 2 formations of Kaeng Krachan group

   - Khao Phra Formation (Pkp) covers most of the Ko Yao Noi areas. Rocks are mudstone, shake, chert and sandstone. Fossils found are bryozoans, brachiopod and crinoids
   - Khao Chao Formation (Pkc) is found in a small area of west Ko Yao Noi. Rock types are quartz sandstone and tuffaceous sandstone with massive bed and cross bedding.

2. **Ratburi group** is found in northern part of Ko Yao Noi and other vicinity islands. There are 2 formations that are presented in Ko Yao Noi.

   - Phab Pha formation (Ppp) consists of limestone and dolomitic limestone with characterized by thin- to medium- bedded. Fossils are bryozoans, fusulinids, corals and crinoids
   - Um Luk formation (Pul) consists of thick sequence of thickly bedded to massive, limestone with chert lens.

3. **Thung Yai Group**; Lam Thap formation is found covering east of Ko Yao Noi. It is unconformably overlain with younger rocks. It is light brown arkosic sandstone with pebbles in some beds interbedded with maroon siltstone, mudstone and conglomerate.

4. **Quaternary**
   - Terrace deposit (Qc) is composed of sand, silt , clay and rock fragments
   - Intertidal deposit (Qmc) is composed of peaty clay, silty clay, sand and rock fragments
   - Alluvial deposit (Qa) is composed of gravels, sand, silt and soil
   - Recent beach sand deposit (Qb) is composed of sand, silt and gravel
   -

Structural geology

The main structures are composed of;

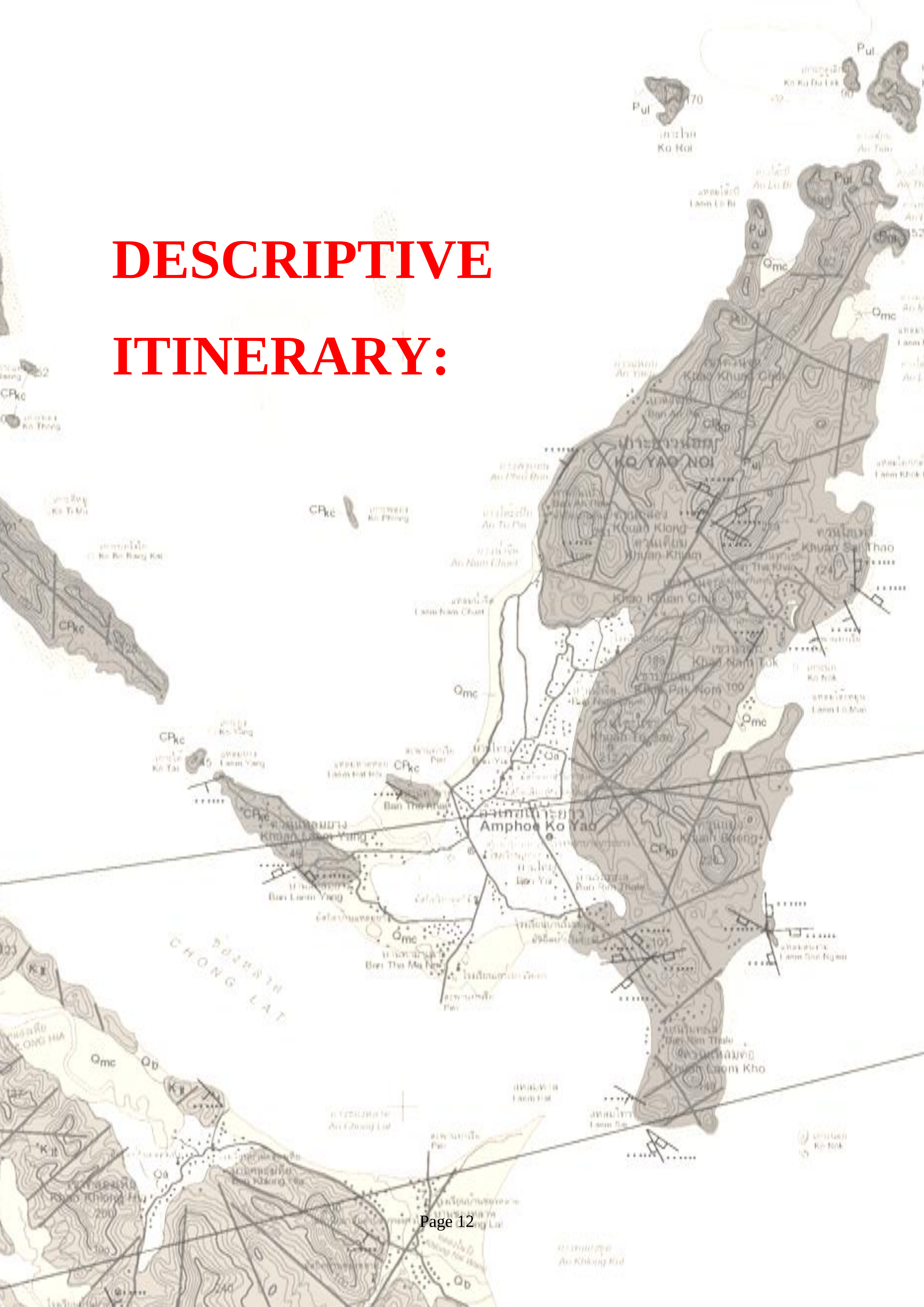
- Discontinuity; There is no evidence that discontinuity has been found in this area. However, it is assumable discontinuity between Permian Ratburi group and Cretaceous Lam Thap formation.
- Bedding; Beds are differentiated in various ways but dip directions are mostly in East and west trend and main strike is in NNE-SSW direction.
- Folding; the stratigraphic and chronologic study suggested that there is no major fold in the area.
- Faults; There are evidences of occurrence of the faults such as small to large fault planes presenting in sandstone and shale. Slickensides which are a smoothly polished surface caused by frictional movement between rocks along the two sides of a fault are also presented. Strike-slip and normal faults are typical in this area.
- Fracture; Mostly oriented in northwest-southeast direction found in all rock types.

Geological map of the Ko Yao Noi

LEGEND

Qb	**Recent Beach deposits:** sand, silt and gravel.
Qa	**Alluvial deposits:** gravel, sand, silt and clay.
Qmc	**Mangrove clay deposits:** perty clay, silty clay, grey or greenish grey, covered with mangrove
Qc	**Colluvial deposits:** silt, sand, clay and rock fragments.
Klt	**Lam Thap Formation :** Arkosic sandstone, light brown, fine- to coarse-grained, partly fine gravels; siltsone, maroon; mudstone and conglomerate.
Pul	**Um Luk Formation:** Limestone, dolomitic limestone, grey and dark grey, massive,partly chert lenses intercarate.
Ppp	**Phap Pha Formation:** Limestone, dolomitic limestone, grey and dark grey, thin- to medium-bedded with fossils of bryozoas, fusulinids, corals and crinoids, partly chert lenses intercarate.
CPkc	**Khao Chao Formation:** Quartz arenite, grey and light grey, fine- to medium grained, thick bedded, with cross-bedding; tuffaceous sandstone, grey, fine-grained.
CPkp	**Khao Phra Formation:** Mudstone; shale, gray and dark gray; chert; sandstone, grey, fine- to coarse-grained, and siltstone intercalated, partly pebbly mudstone, common bryozoas, braciopod, and crinoids.

DESCRIPTIVE ITINERARY:



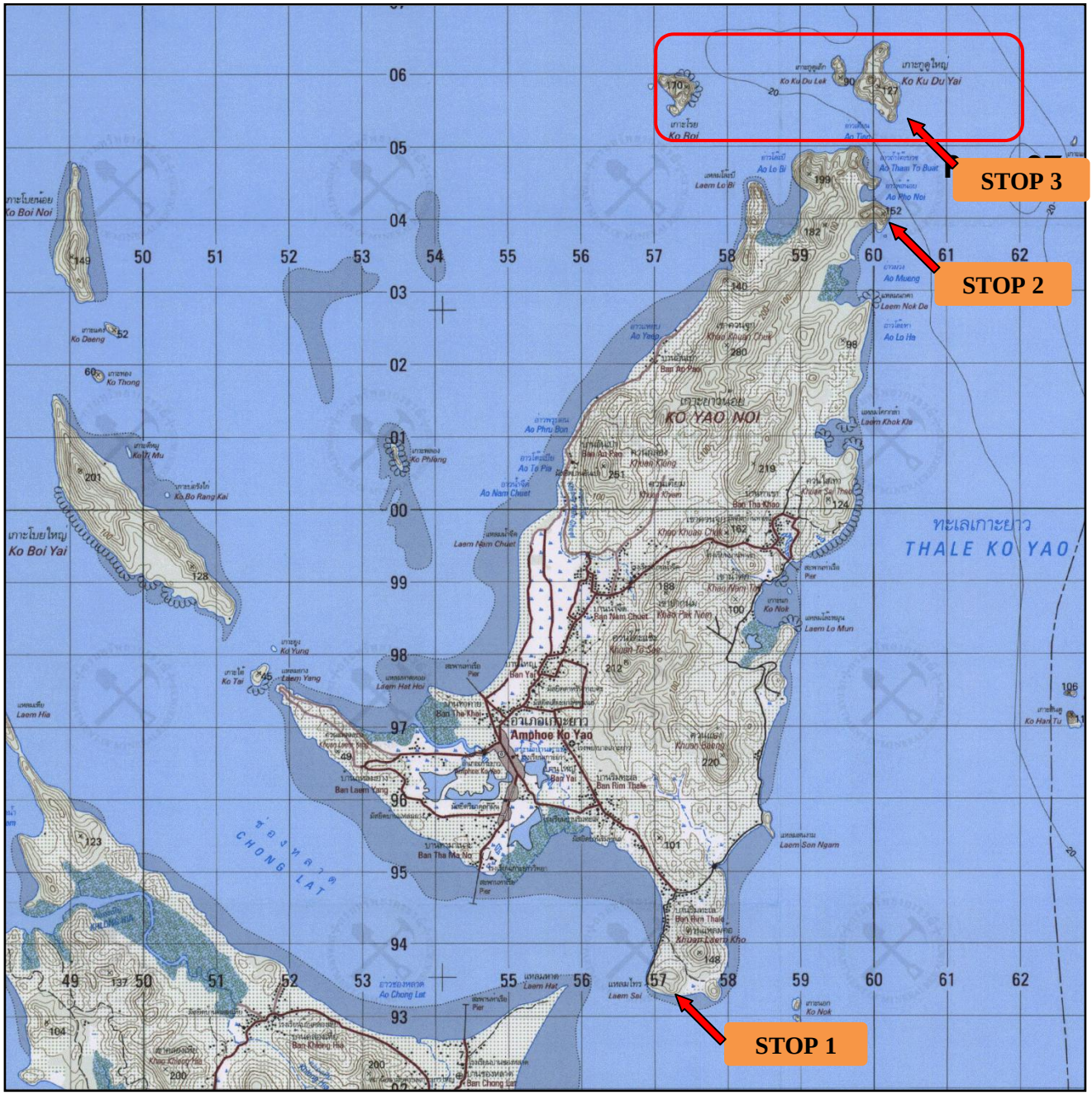
Stop At Ko Yao Noi,

Ko Yao Noi District, Phang-nga Province

STOP 1: Laem Sai, Ko Yao Noi, Phang -nga Province.

STOP 2: Ao Mueng, Ko Yao Noi, Phang -nga Province.

STOP 3: Ko Kudu Yai, Ko Yao Noi, Phang -nga Province.

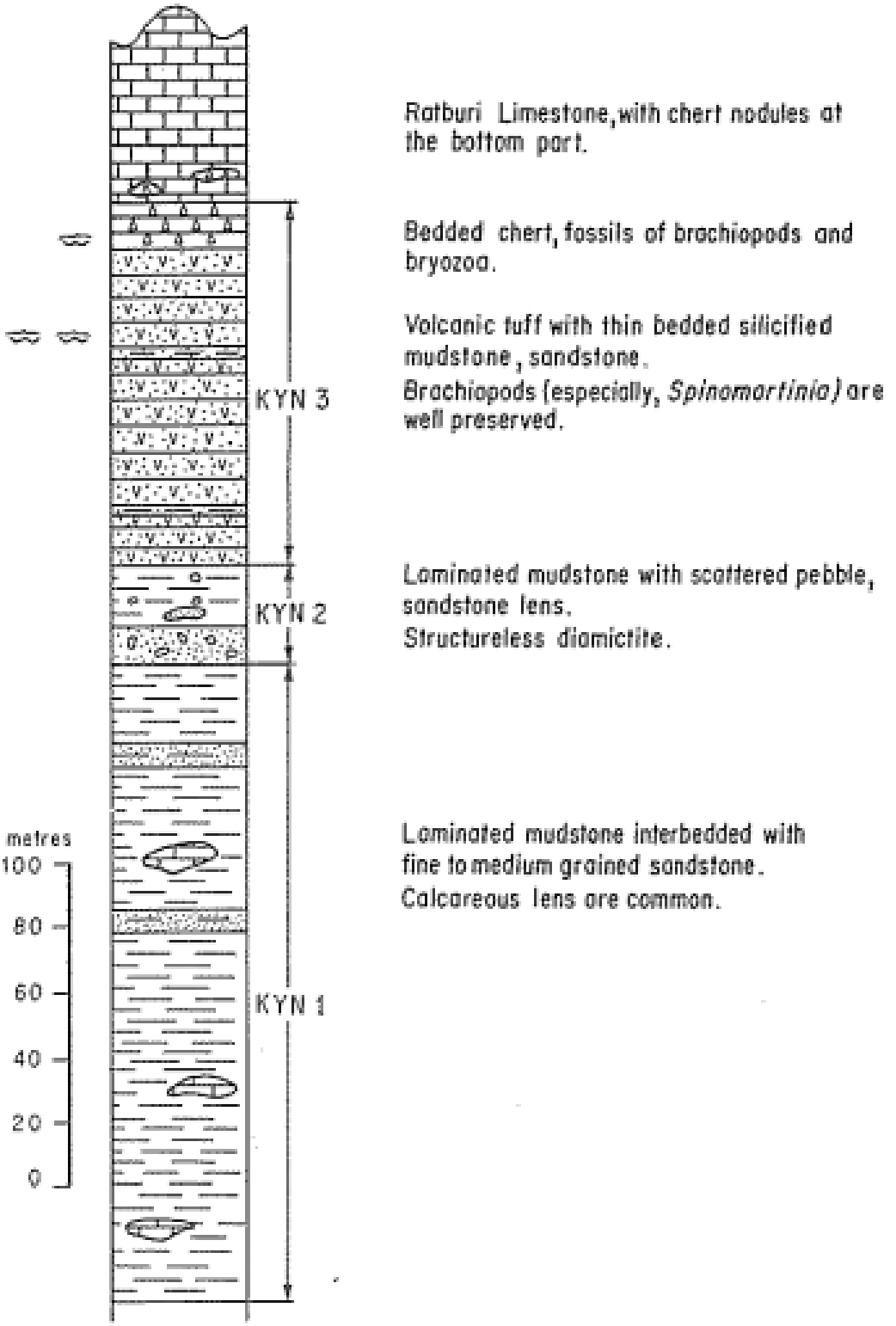


The Ko Yao Noi Formation was named by Pitakpaivan and Mantajit (1981). The thickness of this formation at its type section on Ko Yao Noi is approximately 400 m. The lower part of the formation on the east coast of Ko Yao Noi, is made up of dark gray laminated mudstone interbedded with medium grained sandstone. Some muddy limestone lenses are present. Load casts and flute casts occur in this part.

In Phang-nga Province, The formation was proposed by Waterhouse *et al.* (1981) for "Phuket Group" (namely Kaeng Krachan Group) strata on Ko Yao Noi in Phang-nga Province. In the type area the formation is subdivided into three parts; KYN1. KYN2 and KYN3 in ascending order. KYN1 (200-250m thick) is alternations of dark grey laminated mudstone and medium-grained sandstone with argillaceous calcareous lenses. KYN2 (30-40m thick) consists of pebbly mudstone in the lower part, and gradually changes into alternations of laminated mudstone and sandstone in the upper part. Pebbles are of quartzite, shale, limestone and granite. KYN3 (100-120m thick) is tuffaceous sandstone interbedded with tuff, passing upward into silicified beds. Brachiopods are very abundant in the lower part of KYN 3, which Waterhouse *et al*. (1981) referred to as the *Spinomartinia prolifica Assemblage, typically represented by Retimarginifera alata, Brachythyrina rectangulus, Orthotetes perplexus, Chonetinella andamanensis, Kutorginella paucispinosa K. fraterculus, Stereochia koyaoensis, Spiriferella modesta and Spinomartinia prolifica*. The assemblage was originally assigned to Sakmarian by Waterhouse *et al* (1981). Brachiopod assemblages in KYN3 can be correlated to the Khao Phra Formation in Kaeng Krachan Group by Chaodumrong *et al.* (2004).

The sequence of Ko Yao Noi can be subdivided into three main units namely KYN 1, KYN2 and KYN 3 by Waterhouse *et al*. (1981). The Measured sequence in Ko Yao Noi is as follows:

(4) Permian Limestone (Ratburi Group)	Massive limestone and bedded limestone with chert nodules in the lower part.
	KO YAO NOI FORMATION
(3) KYN 3 (100-120 m)	Tuffaceous sandstone alternating with thin volcanic tuff, passing upward into bedded chert and transitional to Ratburi Group with remarkable chert nodules.
(2) KYN 2 (30-40 m)	Pebbly mudstone in the lower part, laminated mudstones with scattered pebbles and sandstone interbedded.
(1) KYN 3 (200-250 m)	An alternating sequence of dark dray laminated mudstone and medium grained sandstone with argillaceous limestone lenses.



Stratigraphic sequence of Ko Yao Noi

(Waterhouse *et al*.,1981**)**

STOP1: LAEM SAI, KO YAO NOI, PHANG-NGA PROVINCE

Location: Laem Sai, southeast end of Ko Yao Noi, Ko Yao Noi District, Phang -nga Province

Grid ref: 47P 0457063E 0893308N in Amphoe Ko Yao (4725III) Sheet

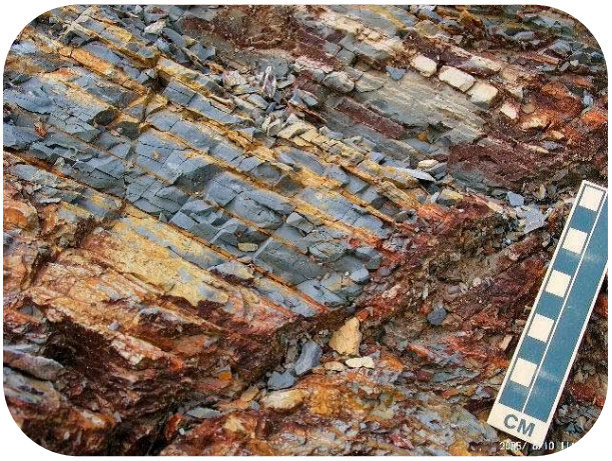
Highlight: The Khao Phra Formation and abundant fossils of *Spinomartinai* sp.

Description:

The rock sequence is defined to correlate with the lower part of KYN3 by Waterhouse *et al.* (1981). The rock sequence is measured to be approximately 10 m in thickness. They comprise sandstone interbedded with laminated mudstone, pebbly mudstone in the lower sequence, and tuffaceous sandstone and tuff with chert in the upper sequence. Tuffaceous sandstone consists of fine- to medium-grained sand with feldspar accounting for 50% of total composition. Brachiopods are abundant in sandstone beds located in the lower part of the strata. A fewer fossil assemblages are presented in higher chert beds. In this locality, the fossil assemblages consist of *Spinomartinia prolifica, Spiriferella modesta, Spinifrons planoconvexa Notothyris hexeris*

The age of the Ko Yao Noi Formation was dated by brachiopods in Ko Yao Noi Island and Ao Nang Bay, Krabi Province to be Sakmarian of Lower Permian (Waterhouse *et al.*, 1981).

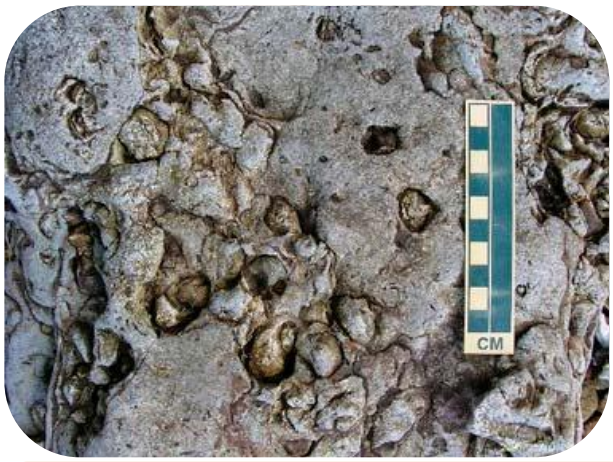
Interbedded mudstone and sandstone with abundant fossils of brachiopods



Laminated mudstone intercalated with sandstone.

Pebbles of quartz in mudstone

Fossil of brachiopods: *Spinomartinia* sp. in sandstone bed



Abundant completely fossils in mudstone bed

Brachiopods in tuffaceous siltstone

Discussion: ……

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STOP 2: AO MUENG, KO YAO NOI, PHANG- NGA PROVINCE

Location: Ao Mueng, Northeast of Ko Yao Noi, Phang- nga Province

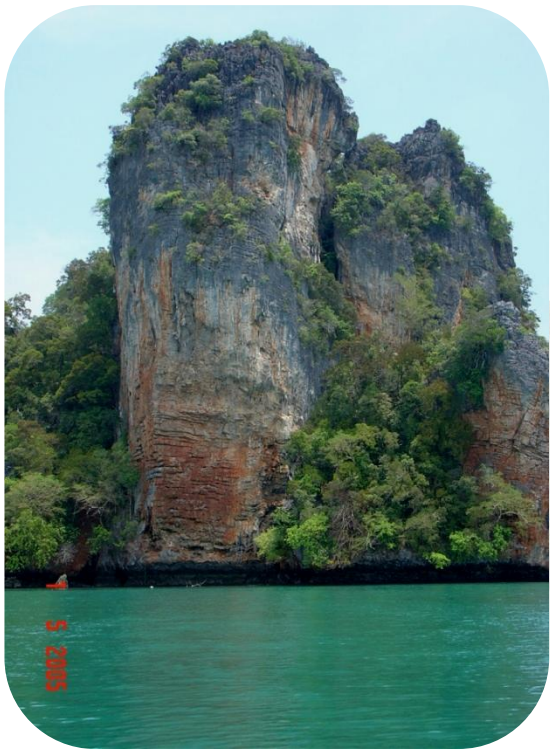
Grid ref: 47P 0459903E 0803880N in Amphoe Ko Yao (4725 III) Sheet

Highlight: Geomorphology of Permian limestone (Um Luk formation, Ratburi Group)

Description:

Ao Mueng is a sequence of Permian limestone sequence which lie N-S trending along Phang-nga bay to small islands in the eastern part of Ko Yao Noi. Geologically, the rock unit represents the upper Formation of the Ratburi Group or so-called the Um Luk Formation. The sequence, approximately 200 m in thickness, is composed of light gray, dense fine-grained, thick- to very thick- or massive-bedded limestone**.** Chert nodules and chert lenses are commonly observed in limestone texture especially in the lower part. Crinoid stems and corals are abundant in their limestone strata.

Chaodumrong et al. (2004) assigned the age of the Um Luk Formation in type locality in Kanchanadit, Surat Thani Province and several areas are Middle Permian. Depositional of this formation is interpreted to be shallow marine environment in lower energy platform.



Geomorphology of limestone of
The Um Luk Formation

Limestone with chert nodules

General views of Ao Mueng (Mueng Bay), northeastern part of Ko Yao Noi

Coral in limestone of
The Um Luk Formation

Another coral in limestone of
The Um Luk Formation

Discussion: ……

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STOP 3: KO KUDU YAI, KO YAO NOI DISTRICT, PHANG NGA PROVINCE

Location: Ko Roi & Ko Kudu Yai , North of Ko Yao Noi, Phang -nga Province

Grid ref: $8^{O}12.000'$N $98^{O}633'$E in Amphoe Ko Yao (4725III) Sheet

Highlight: Beautiful limestone morphology and lagoon at Ko Roi and Ko Kudu

Description:

Rock unit in this stop is a sequence of the two Formation of the Middle Permian Ratburi Group. The lower part is the Phap Pha Formation, consisting of thin to medium bedded (normally less than 20 centimeters thick), dark gray limestone interbedded with shale, mudstone and some chert nodules. The upper part, the Um Luk Formation, approximately 200 m in thickness, is composed of light gray, dense fine-grained, thick- to very thick- or massive-bedded limestone**.** Chert nodules and chert lenses are commonly observed in limestone texture especially in the lower part. Crinoid stems and corals are abundant in their limestone strata.

The unique of this stop is the large twin limestone pillars that stand in the lake. Moreover, other fantastic stone pillars are found in the cliff of Ku Du Island. The shapes of the pillars are affected by rain water and tidal waves and are various depending on the kmagination of the viewers. This stop can be developed as geo-tourism.

Karst Topography of limestone at Ko Kudu Yai

Discussion: ……..…

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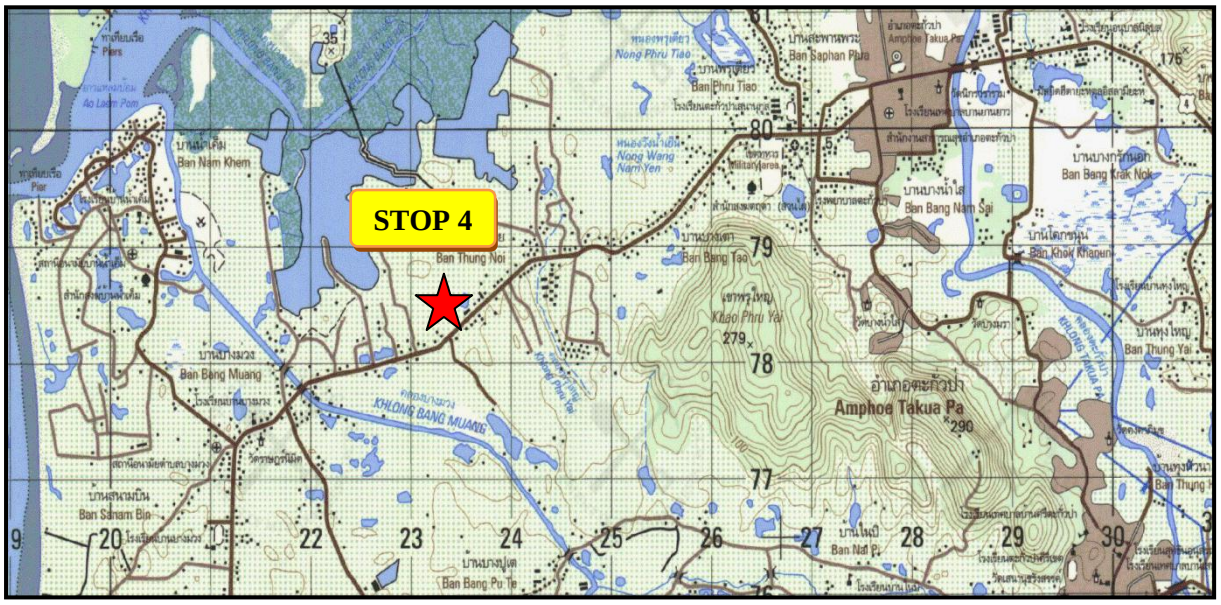
STOP 4: R.A.T. TRADING & MINING (TAKUAPA) CO., LTD., TAKUAPA DISTRICT, PHANG NGA PROVINCE

Location: R.A.T. Trading & mining (Takuapa) Co., Ltd., Takuapa District, Phang -nga Province

Grid ref: 47N 0423668E 0978655N in Amphoe Takuapa (4626 I) Sheet

Highlight: Mineral processing of various heavy minerals



Description:

Established in early 1988, R.A.T. Trading & mining (Takuapa) Co., Ltd. is a subsidiary of Roong Aroon Takuapa Ltd., Part. This originally operated tin mines and mineral processing plant since the mid 1970s. Despite the fact that its business success is greatly achieved, as being awarded "the Best Mining Entrepreneur of the Year" in 1987 by the Ministry of Industry, it is realized that the growth of Roong Aroon Takuapa is limited if neither business structure nor management style were properly adjusted to cope with the changing business circumstances.

Therefore, R.A.T. Trading & Mining (Takuapa) Co., Ltd. is founded to take-over the operations and marketing of mines and mineral processing plant while Roong Aroon Takuapa is dealt only with document management. With the full promotional privileges endorsed by the government's Board of Investment, it is confident that its mineral processing business has a favorable competitive edge in the market.

Resources

Over the years the ores have been mined and shipped abroad as tin-in-concentrates, only small amount of metal ingots was produced. Those leftover materials-"among" by tin separation plants and "slags" from smelting shops were uninterestingly dumped as wastes. In the old days it was not known how large were the reserved quantities of these materials but one could find them easily in the area of abandoned tin mines.

Until the late 1960s, people turned to know the economic values of amang and slag. Apart from being a major source of cassiterite, deposits in this region also contain various grades of valuable minerals including niobium tantalum, titanium, zirconium, tungsten and rare earth elements. Garnet, thorium, uranium and diamond are not uncommon. Nowadays, almost all old slags and amangs were gone. Supply of amangs produced from existing tin mines is also decreasing. Two-third of mining firms are being forced to close the mines due to the depressed tin prices.

This scenario prompted the company to operate its own mines in order to secure its long-term supply of raw materials for the separation plant. It is obvious that offshore mining is the only choice because the deposits there are still economically mineable with comparatively low production cost and less environmental impacts than the onshore operations.

The company and its affiliates have applied for over 20,000 ha.of offshore concessions. Of this area, three mining leases of approximately 2,000 ha are under operation. Estimated ore reserves are sufficient to feed the plant at least throughout the 1990s basing on its current annual production.

Process

The plant is conventional, employing simple techniques to separate to separate and upgrades the mineral to the customers' requirements. These techniques are based on the difference in physical properties among mineral such as specific gravity, magnetic and electrostatic susceptibilities. Main plant machinery includes spiral concentrators, wet and dry magnetic separators, vertical and rotary dryers, wet and air shaking tables, electrostatic separators and high tension separators.

Products and market

There are 8 marketable mineral produced from the production line as follows: Ilmenite (TiO_2 54%, FeO 25%), cassiterite (SnO_2 74 % up), zircon (Zro_2 65%), struverite (Ta_2O_5 8% up), columbite-tantalite (Ta_2O_5 20% up), rutile (TiO_2 90%), monazite (ReO 55% up) and xenotime (Y_2O_3 35% up). The combined mineral' production is approximately 12,000 t output from 15,000-18,000 t raw material feeds. Most minerals are currently marketed to Europe and the Far East, only zircon and cassiterite are consumed by domestic customers.

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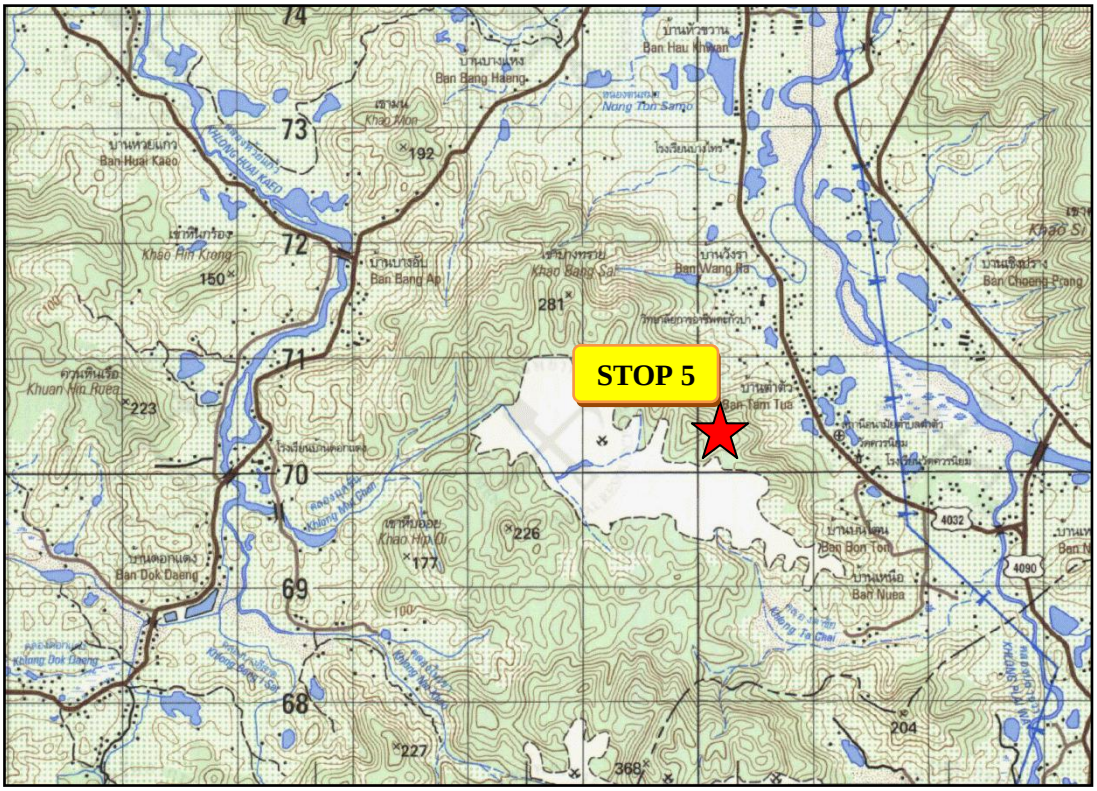
STOP 5: BAN BON TON TIN DEPOSIT, PHANG- NGA PROVINCE

Location: Ban Bon Ton tin deposit is located in Ban Bon Ton, Tam Tua Subdistrict, Takupa District. This area is situated in the Royal Thai Survey Department topographic map L7018 Series, Sheet 4626I (Amphoe Ta Kua Pa)

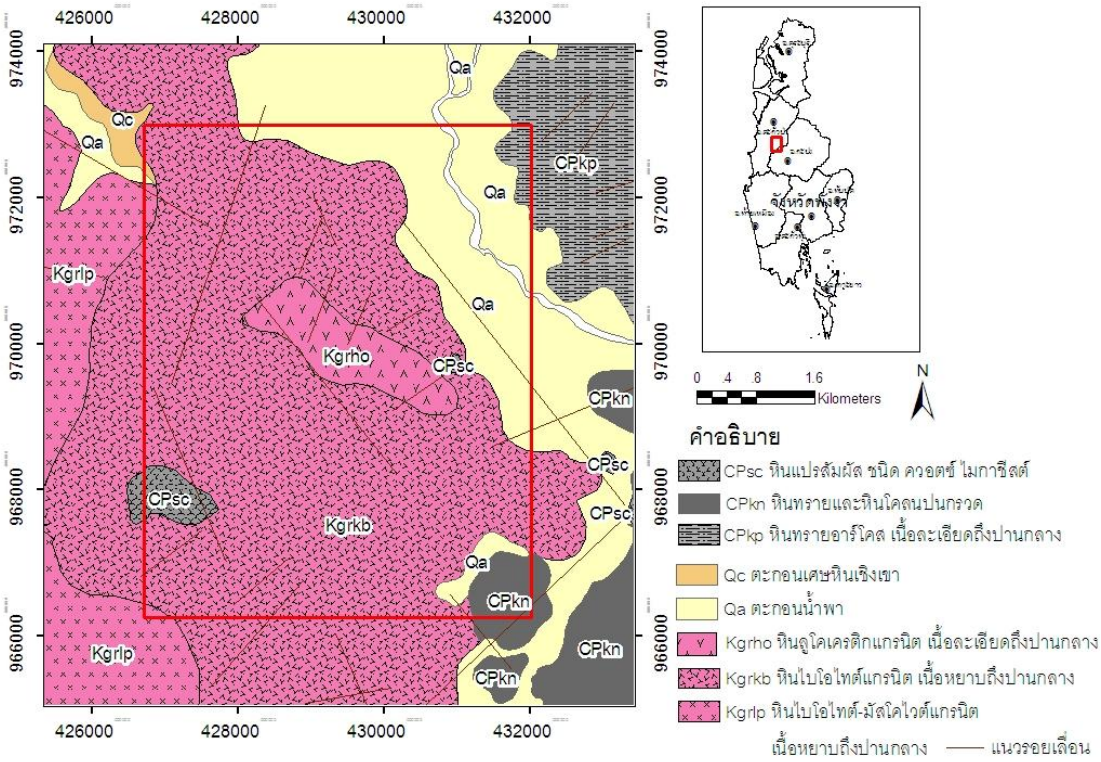
Grid ref: 0430285 East and 969782 North on topographic map L7018 Series, Sheet 4626 I (Amphoe Ta Kua Pa), on 1:50,000 Scale.

Highlight: Pegmatite dikes and quartz veins bearing a various amount of tin.



Exposures of altered granitic rocks (saprolite)

Geology



Description

The geology of the area is consisted of Carboniferous granite. There are two groups of granites; the first group consists of porphyritic biotite granite which has a medium- to coarse- grained groundmass; while the second group consists of leucocratic granite. The granite is intruded into Carboniferous-Permian sedimentary rocks including sandstone and shale. Near the granite contacts these rocks have been altered by the tectonic and resulting in dominant Northwest-Southeast fault sets. Hydrothermal solutions traversing through fractured rocks/fault sets, either together or separately, both the granite and the adjacent country rocks in a number of places created Pegmatite dikes and quartz veins bearing a various amount of tin.

Granite with pegmatite/quartz veins

The width of the pegmatite dikes range from a few 7-50 cm. They appear to be two principal orientations of dikes. One is striking about northwest – southeast direction which conforms to the main primary fault set. The other striking northeast conform the secondary fault set. In some areas, mineralization can also be found as stockwork. The width of the tin-quartz veins ranges from 0.3 to 3 m. Their orientations are in the same directions as pegmatite dikes.

Close-up Pegmatite veins with Tourmaline

Cassiterite occurs as a primary constituent of both pegmatites dikes and quartz veins and in the wall rock bordering the veins. The pegmatites dikes and quartz veins occur both in the granite and in the metasedimentary host rocks near the granite contacts. Moreover, Erosion has concentrated the cassiterite into eluvial (residual), colluvial (hillside creep), and alluvial (stream transported) placers. The minerals are still in well-developed crystals and these placers are rich ore minerals.

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STOP 6: HOT SPRING, BAN PLAI PHU, KA PONG DISTRICT, PHANG-NGA PROVINCE

Location: The hot spring is situated in Ban Plai Phu, Thana subdistrict, Ka pong District, Phang-nga Province. It is just 8 km from Ka Pong district by taking the highway to Ban Plai Phu.

Grid ref: 47N 0441058E 0960842N on the topographic map; sheet 4626 II (Amphoa Ka Pong)on scale 1:50,000.

Highlight: Attraction place for tourism in Ka Pong District

Geology:

The hot spring lies on the contact between Carboniferous-Permian sedimentary rock including sandstone and dark grey conglomeratic siltstone, and Biotite-hornblende granite of Cretaceous. There are gravels of granite and sandstones along the stream. The size ranges from gravel to boulder.

Description:

The site is characterized as a channel which contains a faint smell of sulfur. This hot spring is caused by hot water springs up along the channel and then is mixed with the water flowing from the main stream. Therefore, the water is not too hot. There are spots of smoke presenting along the channel. On the level besides the stream, concrete wells are built in order to contain hot spring water that bobbed up. This water temperature is about 60-70 degrees Celsius. Eggs can be cooked in this temperature.

Hot Spring Ban Plai Phu is geological resources which should be developed to become a geological educational site coupled with travel because of its diversity of geology such as geothermal, Mineral resources, geomorphology as well as geohazard potential site study including landslide. Moreover, the site is easily accessed and has all facilities for tourism

Discussion: …….....

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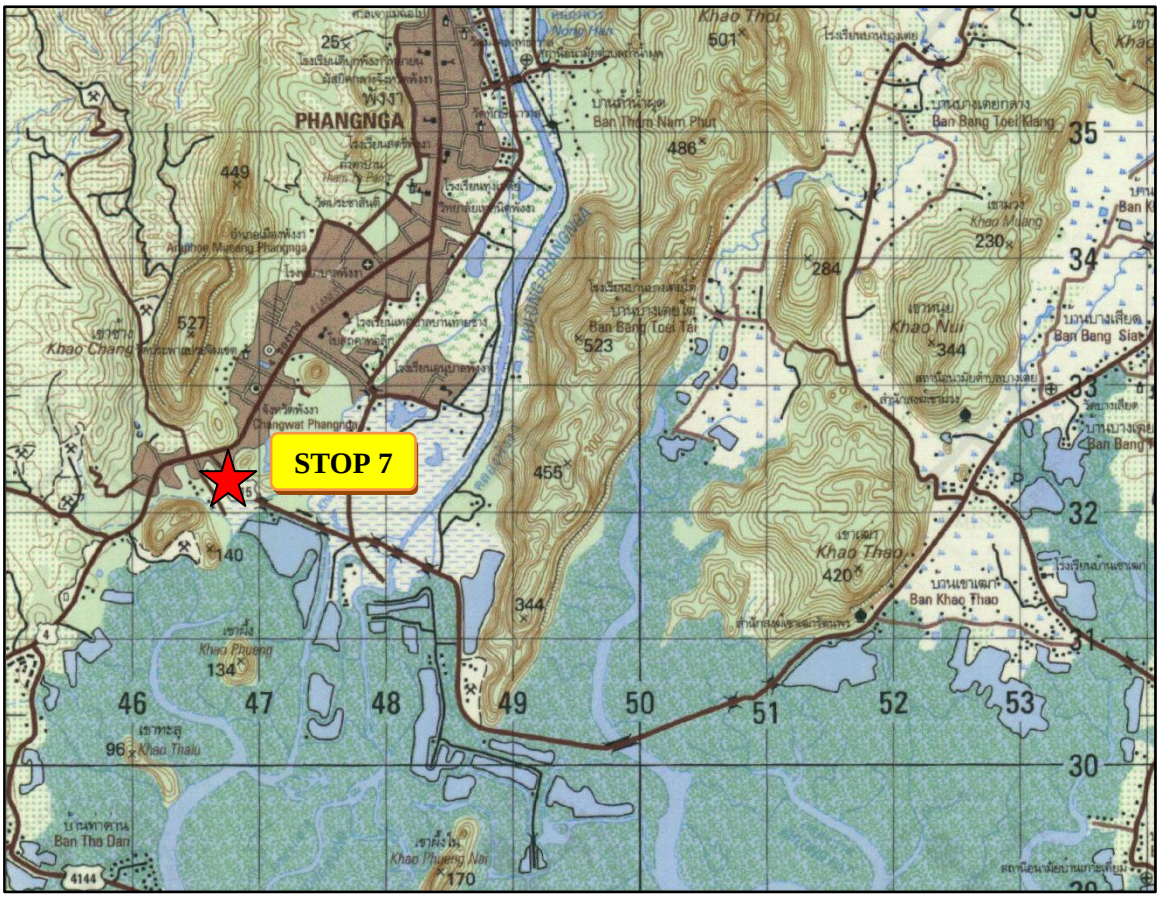
STOP7: SOMDET PHRA SRI NAKARIN PARK, MUEANG DISTRICT, PHANG-NGA PROVINCE

Location: Somdet Phra Sri Nakarin Park is situated in the Phang-nga municipal, Mueang District, Phang-nga Province

Grid ref: 47N 0477020E 0932650N on the topographic map; sheet 4725 IV (Changwat Phang Nga) on scale 1:50,000.

Highlight: Stone park of the Permian limestone sequence in Phang-nga Province



General view of the stone park in Phang-nga Province

Description :

Somdet Phra Sri Nakarin Park is situated in the Phang-nga municipal, Mueang District, Phang-nga Province. The park is located on the highway number 4, about 800 m southwest of the city hall. There are lots of big trees and other smaller trees of which are newly planted. There is also a pond which created by natural cracks. This park is surrounded by incredibly beautiful limestone mountain. Therefore, there are several caves of which inside are stalagmites and stalactites, and meandering streams that trickle through the caves. This area is under the influence of the tide. Therefore, water in this is composed of freshwater, brackish water and seawater.

Limestone Mountain poses continuously with a limestone islands in Phang -nga Bay, which is located nearby. Dark gray limestone has been mapped as Permian age in the range of about 250-280 million years. The Karst topography is a distinctive topography in which the landscape is largely shaped by the dissolving action of acid water. Rainwater becomes acidic as it comes in contact with carbon dioxide in the atmosphere and the soil. As it drains into fractures in the rock, the water begins to dissolve away the rock creating karst topography. Structures created by the deposition of slowly dripping calcium carbonate solutions are stalactites and stalagmites. While at the base of the mountain being erode by seawater due to the influence of the tide, causing the underpass connecting caves in the limestone mountain

Discussion: …….....

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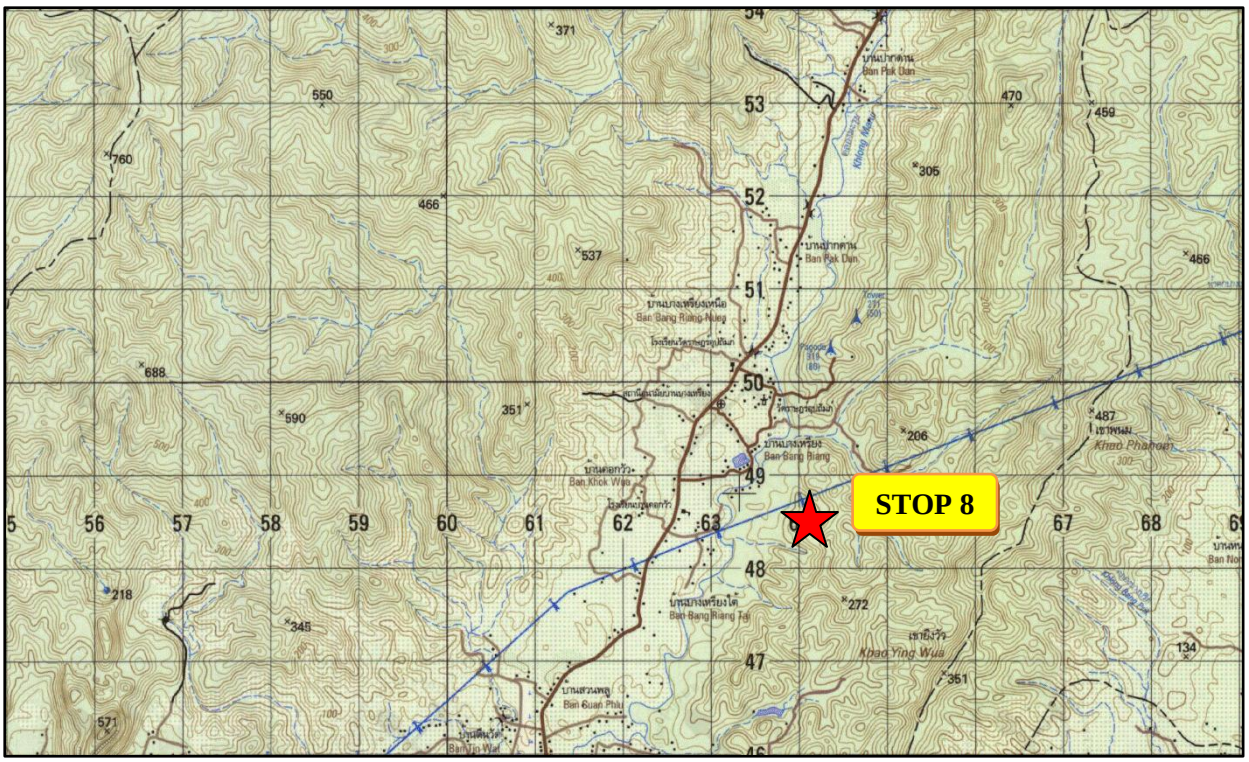
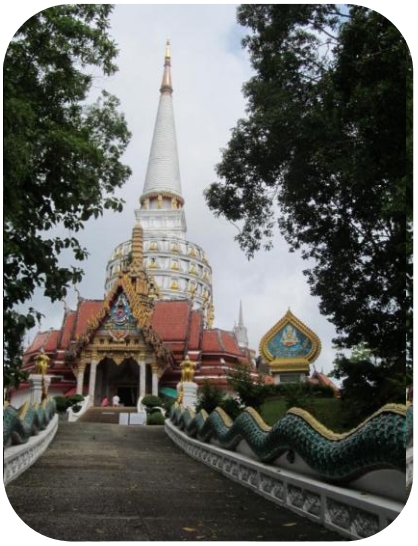
STOP 8: GEOMORPHOLOGY OF THE ACTIVE FAULT IN BANG RIANG TEMPLE VIEW POINT, THAP PUT DISTRICT, PHANG NGA PROVINCE

Location: Bang Riang Temple, Thap Put District, Phang Nga Province.

Grid ref: 47P 0464399E 0952424N on the topographic map; sheet 4725 IV (Amphoe Thap Put) on scale 1:50,000.

Highlight: Geomorphology of the Khlong Marui Active Fault which pass along to the edge of intermontane basin





View point of the Bang Riang Temple showing Triangular facet morphology

Description:

Khlong Marui fault zone is a strike-slip fault the parallel with the Ranong fault zone in a NE-SW direction. It extends from Phuket and Phang-nga provinces on the Andaman Sea to the Gulf of Thailand in Surat Thani province. The movement of this fault zone was dextral probably resulting from the subduction of the Indian-Australian plate beneath the Eurasian plate at the Andaman ocean trench. Department of Mineral Resource (2008) summarized the characteristic of geomorphic feature, Maximum Paleoearthquake, age, slip rate and recurrence interval of the Ranong and Khlong Marui Fault zones. Detailed of the study are illustrated as follow;

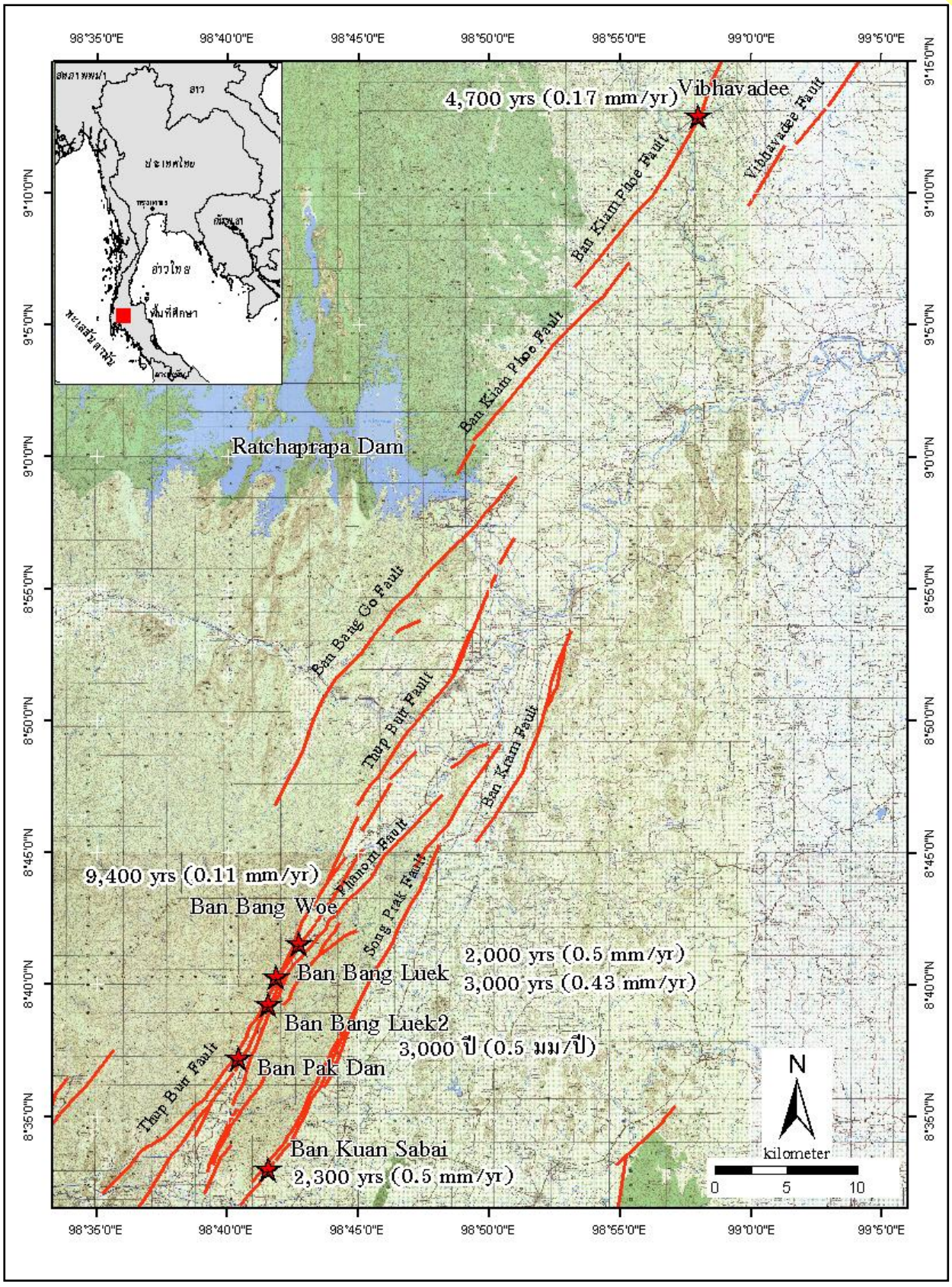
a) Geomorphic Features and Maximum Paleoearthquake Magnitudes

Khlong Marui Fault has the total length of about 180 km and consists of 10 segments. The maximum paleoearthquake magnitudes can be estimated from the length of fault segments deduced from remote sensing interpretation that The Khlong Marui Fault generated several paleoearthquakes with magnitudes of about 6.3 to 7.2.

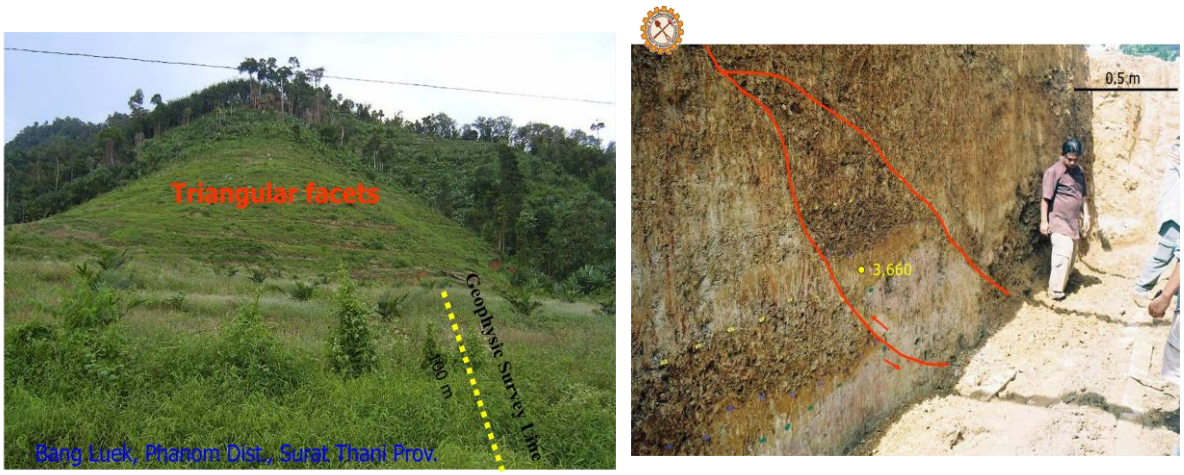
Results of investigation at Ban Bang Luek reveal the occurrence of Thap Put fault segment with the orientation in the northeast – southwest direction. The surface fault length is about 450 m. The main morphotectonic features include triangular facets and offset streams. The main structures in the exploratory trenches are two faults cutting E unit showing the fault planes with the attitudes of $52^0/46^0$ SE and $30^0/35^0$, and one is observed to cut across Unit J with the attitude of $55^0/56^0$ SE .

b) Age, Slip Rates and Recurrence Interval of Active Fault

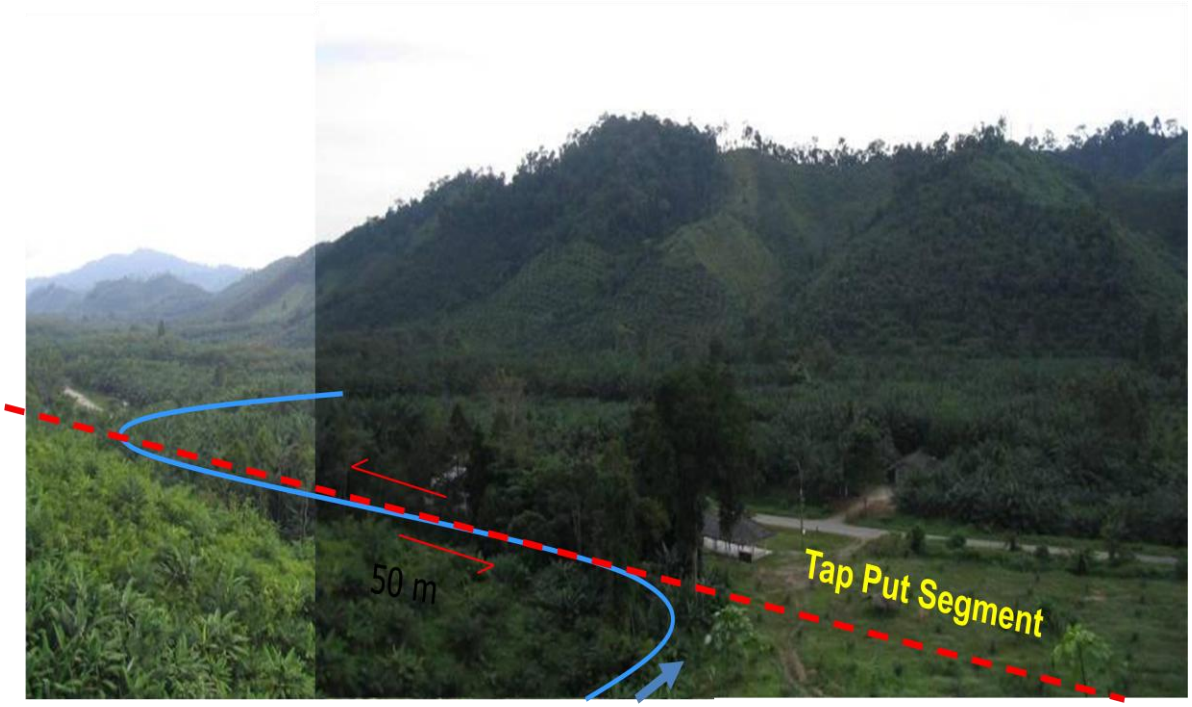
The first earthquake event of the Khlong Marui Fault Zones took place at about 9,000 yrs ago based on the offset sedimentary layers and the TL and C-14 AMS dating methods from two trenchs. It is estimated base upon both offset length and dated faulting layers that slip rate are about 0.18 mm/yr. The second earthquake events occurred at about 4,700 yrs ago based on the results of exploratory trench. The result of trenching investigation reveals two active fault branches Kiam Phoe segment of the Khlong Marui fault. This gives rise to the calculated slip rate to be about 0.17 mm/yr. The third earthquake event of the Ranong-Khlong Marui Fault Zones took place at about 2,700 – 3,000 yrs ago. Faulting of this event by C-14 AMS dating occurred at least 2 places namely the Thap Put segment of the Khlong Marui fault. The last earthquake in area dominated by the Khlong Marui Fault Zones happened at about 1,000-2,000 yrs ago. Slip rate of estimated using the age of sediments and their offset to be about 0.5 mm/yr.



Active Fault Map of the Southern of Khlong Marui Fault in Phang-nga-Surat Thani Provinces
Each active fault (red line) indicates the left-lateral movement.



Trench of the sediment in undulating terrain along the Khlong Marui Fault zone, Ban Bang Luak, Phang- nga-Surat Thani Provinces. The profile showing the movement of young quaternary sediments (red lines)



Offset Stream and triangular facets located in Thab Put - Pranom Districts, Phang-nga-Surat Thani indicating the characteristic of active fault in Khlong Marui fault zone.

Discussion……

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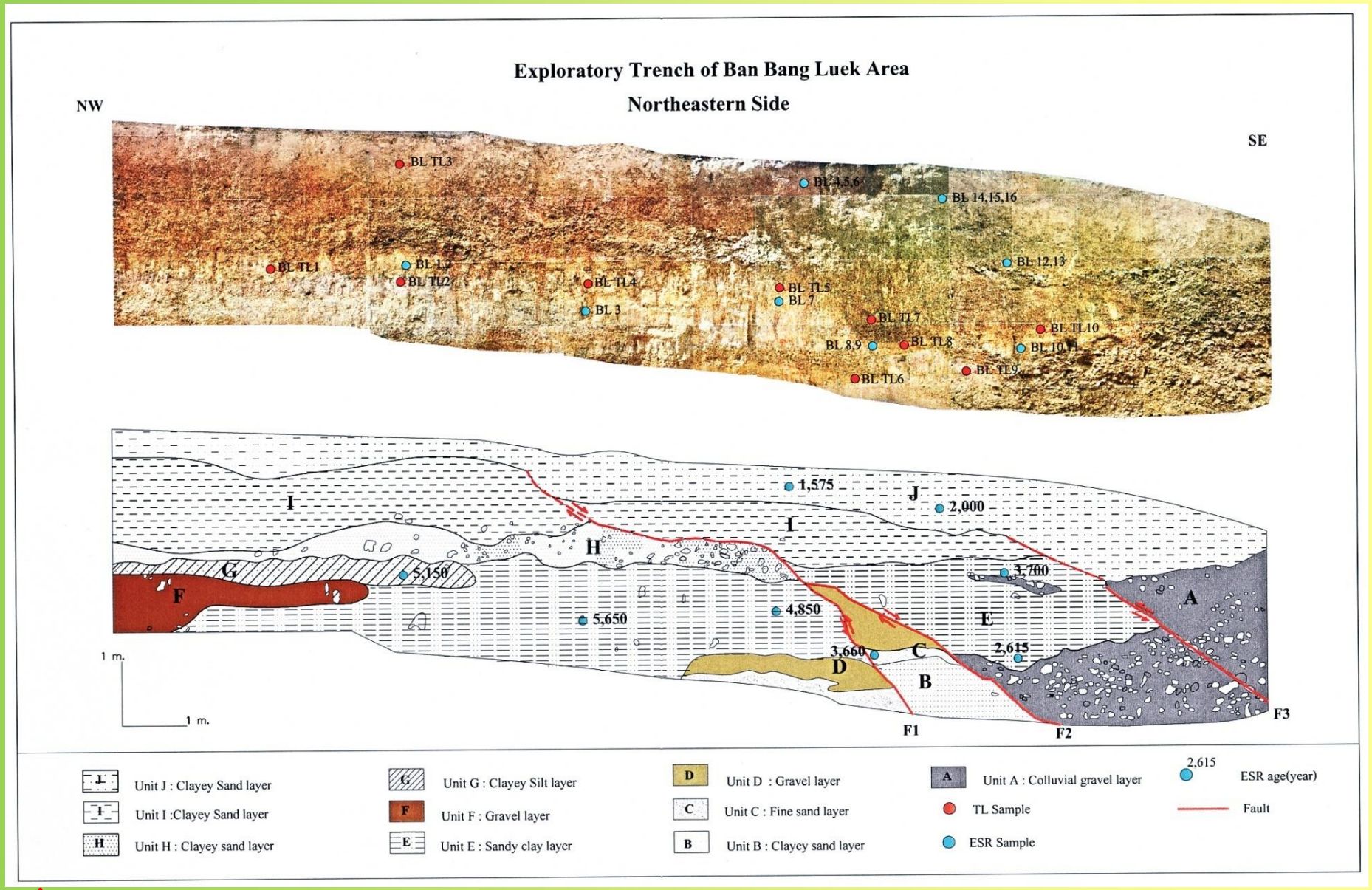


Northeastern side of trench showing sediment stratigraphy, structures and locations of collected samples for dating, Ban Bang Luek, Tambon Plu Thoen, Amphoe Phanom, Surat Thani.

STOP 9: BRACHIOPOD SITE OF THE AO NAM AREA, KRABI PROVINCE

Location: Ao Nam, Ban Ao Nam, Laem Sak Subdistrict, Ao Luek District, Krabi Province

Grid ref: 47P 0459995 E 0920429 N on the topographic map; Changwat Phang-nga Quadrangle (4725 IV) on scale of 1:50,000.

Highlight: Fossiliferous beds of the Early Permian Rock.

Chonetinella cf. *andamanensis*

Stictozoster cf. *leptus* ?

Retimarginifera cf. *alanta*

Description:

The area is predominantly covered by sedimentary rocks ranging in age from the Early Permian to Quaternary, in ascending order. They include the Lower Permian Khao Phra Formation (the Kaeng Krachan Group), the Middle to Upper Permian Ratburi Group, the Cretaceous Lam Thap Formation (the Thung Yai Group) and the Quaternary sediments including colluvial and tidal flat deposits.

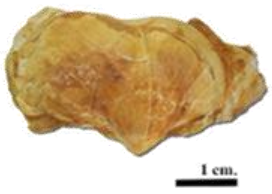
Marine Permian rocks belonging to the Khao Phra Formation of the Kaeng Krachan Group are well exposed at Ban Ao Nam, Ao Luek District, Krabi Province, Southern peninsular Thailand. The rocks are unconformably underlain by the Ko He Formation, but conformably overlain by the limestone of theRatburi Group. Lithostratigraphically, the sequence can be divided into five units, respectively in ascending order: Ao Nam 1, Ao Nam 2, Ao Nam 3, Ao Nam 4, and Ao Nam 5, consisting mainly of sandstone, siltstone, and mudstone with total thickness of approximately 77 m.

These rocks contain faunal assemblages of brachiopods, bryozoans, crinoids, and trilobite fragments, of which brachiopods are abundant. Seven hundred and eighty six specimens of brachiopods have been collected and can be identified into 38 species. Of these, *Kutorginella* cf. *paucispinosaI* and *Chonetinella* cf. *andamanensis* are dominant and abundant with more than 100 specimens or 32% of the total specimens collected. *Orthotetes* cf. *perplexus*, *Stereochia* cf. *kaoyaoensis*, *Spiriferella* cf. *modesta*, and *Spinomartinia prolific* range from 50-100 specimens or 39% of the total. *Linoproductus* sp is represented by 47 specimens, constitutes 6% of the total. *Stenoscisma* cf. *quasimutabilis*, *Anomaloria* cf. *glomerosa*, and *Hustedia* cf. *ratburiensis* are approximately represented by 25 specimens, constitute 10% of the total. Other species include, less than 25 specimens or 13% of the total, *Rhipidomella* cf. *cordialis*, *Schuchertella* cf. *cooperi*, *Derbyia* cf. *scobina*, *Meekella* cf. *bisculpta*, *Perigeyerella* cf. *tricosa*, *Demonedys* cf. *fastigiata*, *Tornquistia* cf. *tricorporun*, *Stictozoster* cf. *leptus*, *Comuquia* cf. *modesta*, *Dyschrestia* cf. *spodia*, *Marginifera* cf. *nesiotes*, *Retimarginifera* cf. *alanta*, *Caricula* cf. *salebrosa*, *Bibatiola* cf. *costata*, *Celebetes* cf. *gymnus*, *Rigbyella* cf. *crassa*, *Pontisia* cf. *exoria*, *Goleomixa* cf. *acymata*, *Cruricella* cf. *couria*, *Cleiothyridina* cf. *seriat*, *Composita* sp, *Permophricodothyris* cf. *notialasistica*, *Brachythyrina* cf. *rectangulus*, *Grantonoa* sp., *Martiniopsis* cf. *trimmata*, *Callispirina* cf. *austrina*, *Paraspiriferina*, *Hemiptychina* cf. *murrita*.

Based on faunal assemblages and lithologies, the rocks have been interpreted as having been deposited in shallow marine and shelf environments in the Early Permian age.

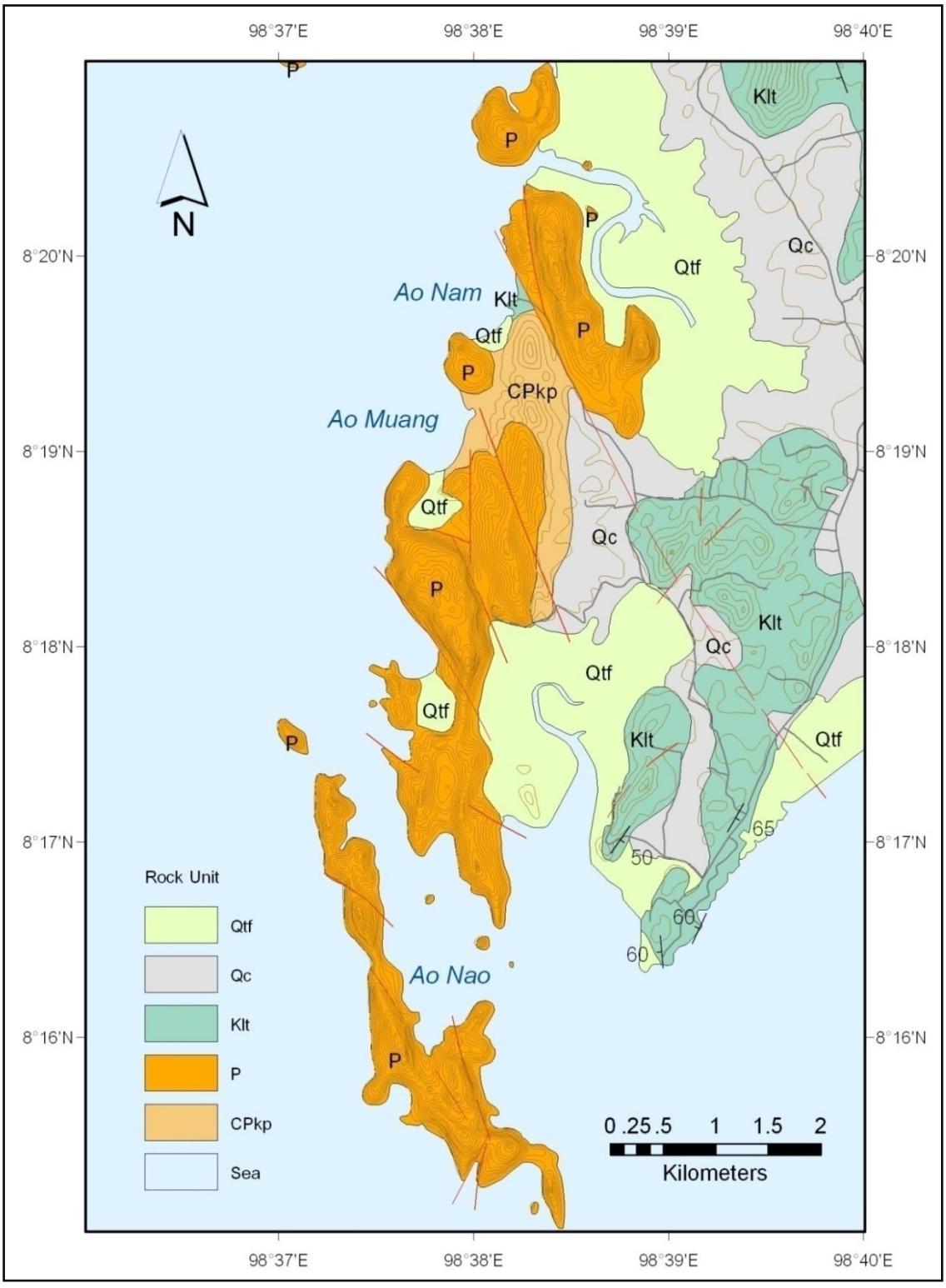
The presence of Early Permian brachiopods at Ban Ao Nam is classified as one of the most important fossil sites in southern Thailand in terms of abundance and diversity. This site is not only for academic study but is also suitable for promoting as a tourist site, and a fossil site under the Fossil Protection Act., B.E. 2551.

Kutorginella cf. *paucispinosa*

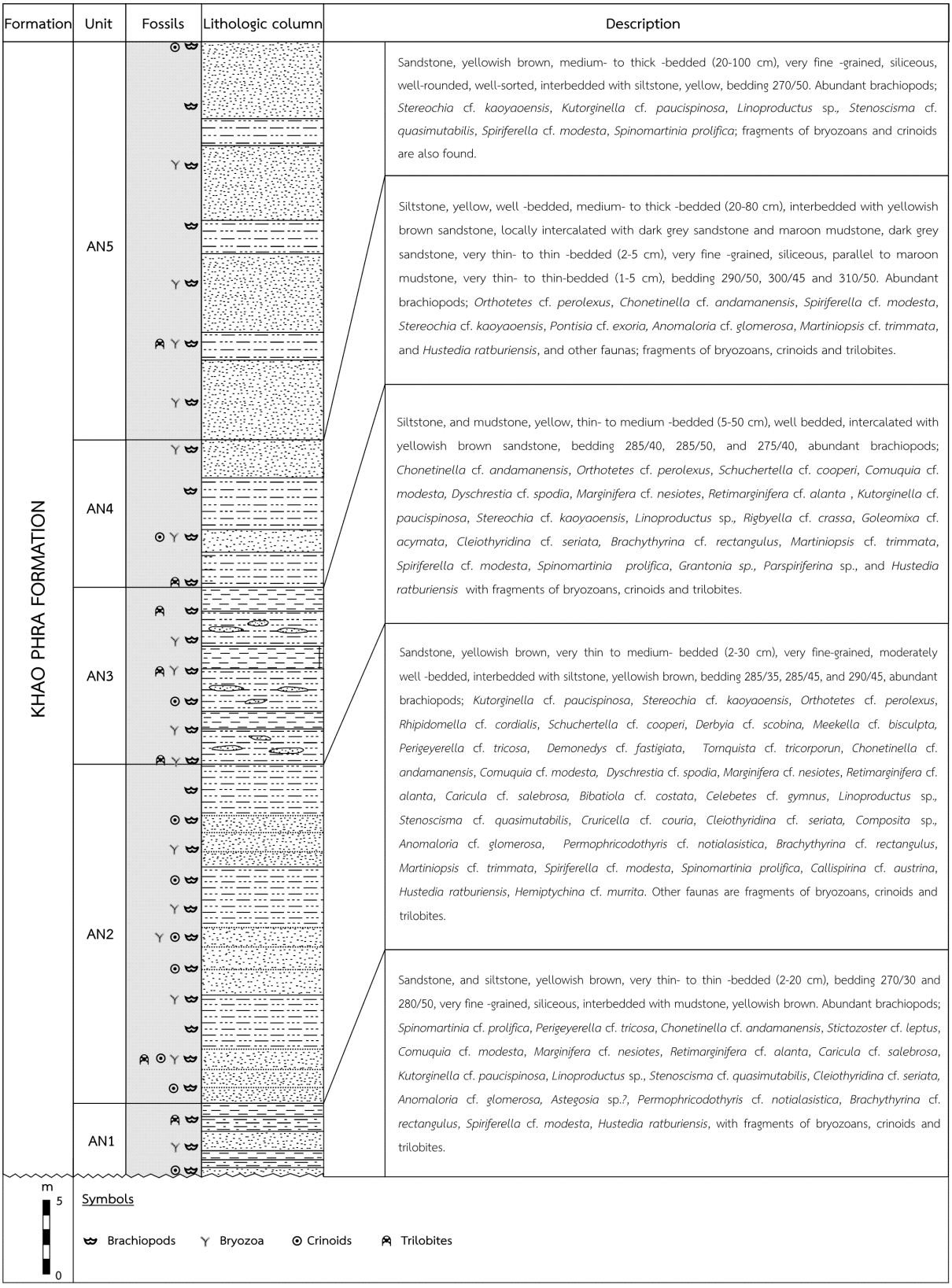


Spinomartinia prolifica

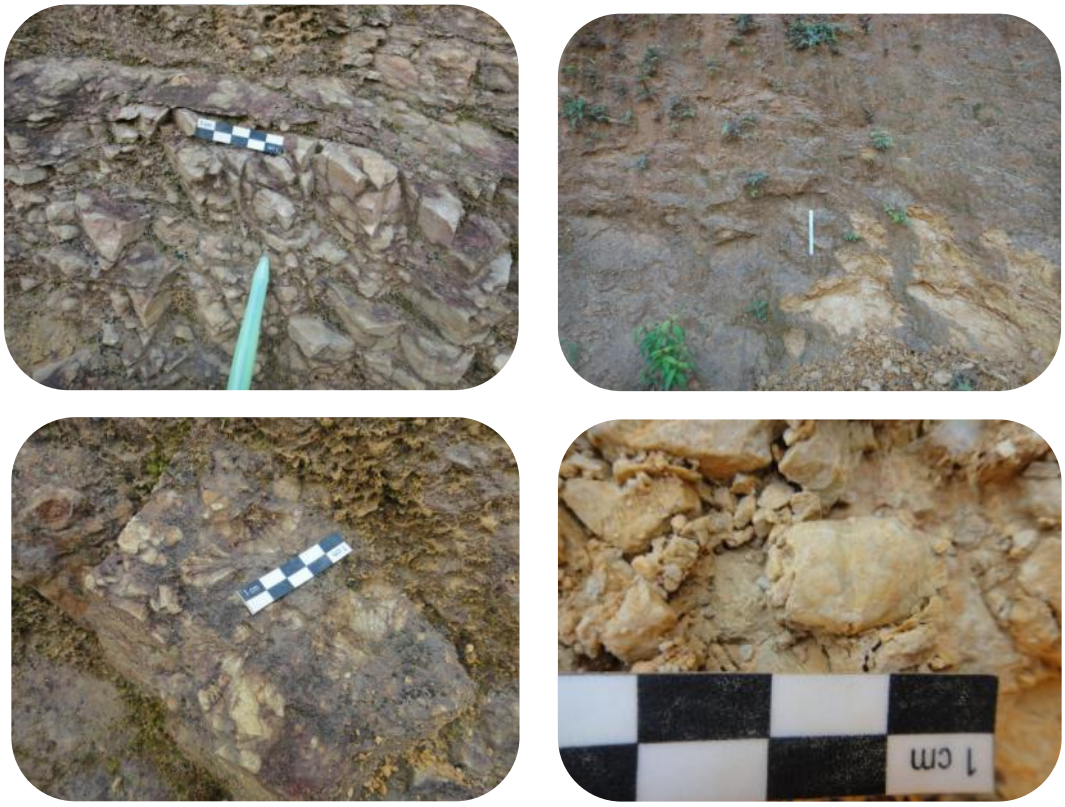
Spiriferella cf. *modesta*



Geological map showing distribution of the rock units within the study area where the brachiopod site is located (modified after Assavapatchara et al., 2006).



Photograph showing the geologic column of the Khao Phra Formation at the study area of Ban Ao Nam, Laem Sak Subdistrict, Ao Luek District, Krabi Province.



Example of exposure and fossil assemblages in Ao Nam area

Discussion……

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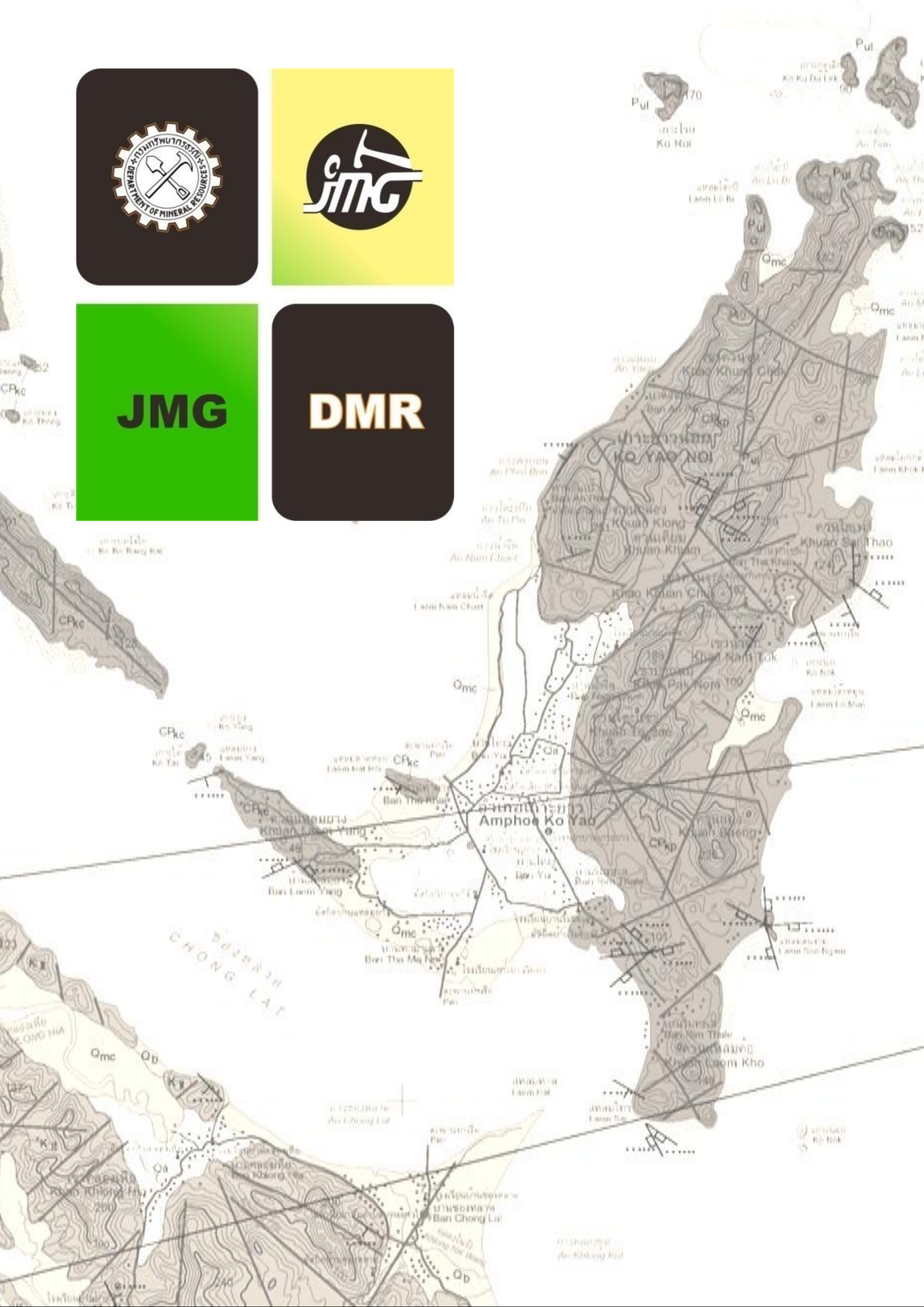
EXCERPT PAPERS

1. Granites and associated mineral in Thailand
   By Somchai Nakapdungrat and Prinya Putthapiban

2. Permian limestones of Surat Thani Province, Peninsular Thailand
   By Fontaine Henri, Hoang Thi Than, Sirot Salyapongse, Varavudh Suteethorn and Daniel Vachard

JMG

DMR



KO YAO NOI
Amphoe Ko Yao
Khuan Khiam
Khao Khuan Chik
Khuan Sai Thao
Khuan Laem Yang
Ban Laem Yang
Ban Tha Khao
Ban Chong Lat
CHONG LAT
Ko Roi
Laem Nam Chuet