

CHAPTER 1  
INTRODUCTION



The peninsular Thailand has long been known as one of world famous tin-belts, and tin mining activities have been carried out for a few hundred years, However, the state-of-the-art of geology of this region is poorly defined, especially in the area under the present investigation of Nakhon Si Thammarat, Krabi, and Trang.

In the Middle Triassic time, the Shan-Thai block was in contiguous to Indochina and South China blocks. The continent-continent collision was a part of the Indosinian orogeny. After the collision, mountains were developed along the suture, particularly along the over-thrusting Shan-Thai margin. At the same time granites were intruded to high levels in the sediments, and the extensive rhyolites were extruded on the land surface. Erosion of the mountain produced mollasse deposits on both sides of the suture (Chuaviroj,1990). The mollasse deposits are mostly developed in the Khorat Plateau which was formed on the western side of underthrusting Indochina block. And the continental Mesozoic red beds are widely distributed throughout the country. The distribution was noted in 8 areas (Bunopas,1976), namely: The Khorat Plateau, Uttaradit-Dan Sai Synclinorium, Nan-Phrae-Chiang Rai area, Lampang area, Tak area, Kanchanaburi area, Trat-Cambodia area and Chumphon-Nakhon Si Thammarat area, the rocks are predominantly red clastic, i.e., sandstone, siltstone, claystone, shale and conglomerate.

Despite the fact that numerous investigations have been conducted over the last four decades in this region, systematic stratigraphic investigation of the non-marine Mesozoic deposits has rarely been carried out. This may be due to many reasons, namely, the area had been inaccessible for along period of time from

communist insurgency, the discontinuities of exposures of sedimentary sequences, and the thick soil covers as well as the dense tropical rain-forest.

The present investigation attempts to conduct the systematic stratigraphic study of the area in order to serve as the background geology of the non-marine Mesozoic deposits. Besides, the information obtained from the present study might help to gain a better understanding on the economic implications of these sedimentary sequences as the potential petroleum source rocks and the origin of gypsum/anhydrite deposits particularly the transitional succession in the lowermost part of neighbouring areas.

### 1.1 Study Area

The study area is located in peninsular Thailand extending from Chumphon-Nakhon Si Thammarat-Krabi to Trang provinces (Figure 1.1) with particular emphasis on, Thung Yai of Nakhon Si Thammarat and Khlong Thom of Krabi area. It is between latitudes  $7^{\circ} 52' 49''$  N to  $8^{\circ} 15' 04''$  N, and longitudes  $99^{\circ} 08' 17''$  E to  $99^{\circ} 35' 40''$  E and covers topographic map sheets Ban Thang Lung (4825 II), Ban Nua Khlong (4825 III) and Khao Noi (4824 I) on the scale of 1:50,000. The study area covers approximately 1,160 square kilometres, and can be accessed by highway nos. 4 and 41.

The topography of the area is generally high mountainous and undulating landforms, the maximum elevation is at Khao Sam Chom (754 metres MSL). The southwestern part of the area near Khlong Thom of Krabi is largely covered by mangrove whereas the western part is mostly undulating landform. The middle and eastern parts of the study area are bounded by mountains of clastic/carbonate rocks of Permian-Cretaceous age, namely, Khao Khao, Khao Tao, Khao Hin Luk Chang, Khao Sam Chom, and Khao Prik. The main river system flowing to the north and northeast is Khlong Min, Khlong Chi while Khlong Lam Dang flows eastwardly. In the western

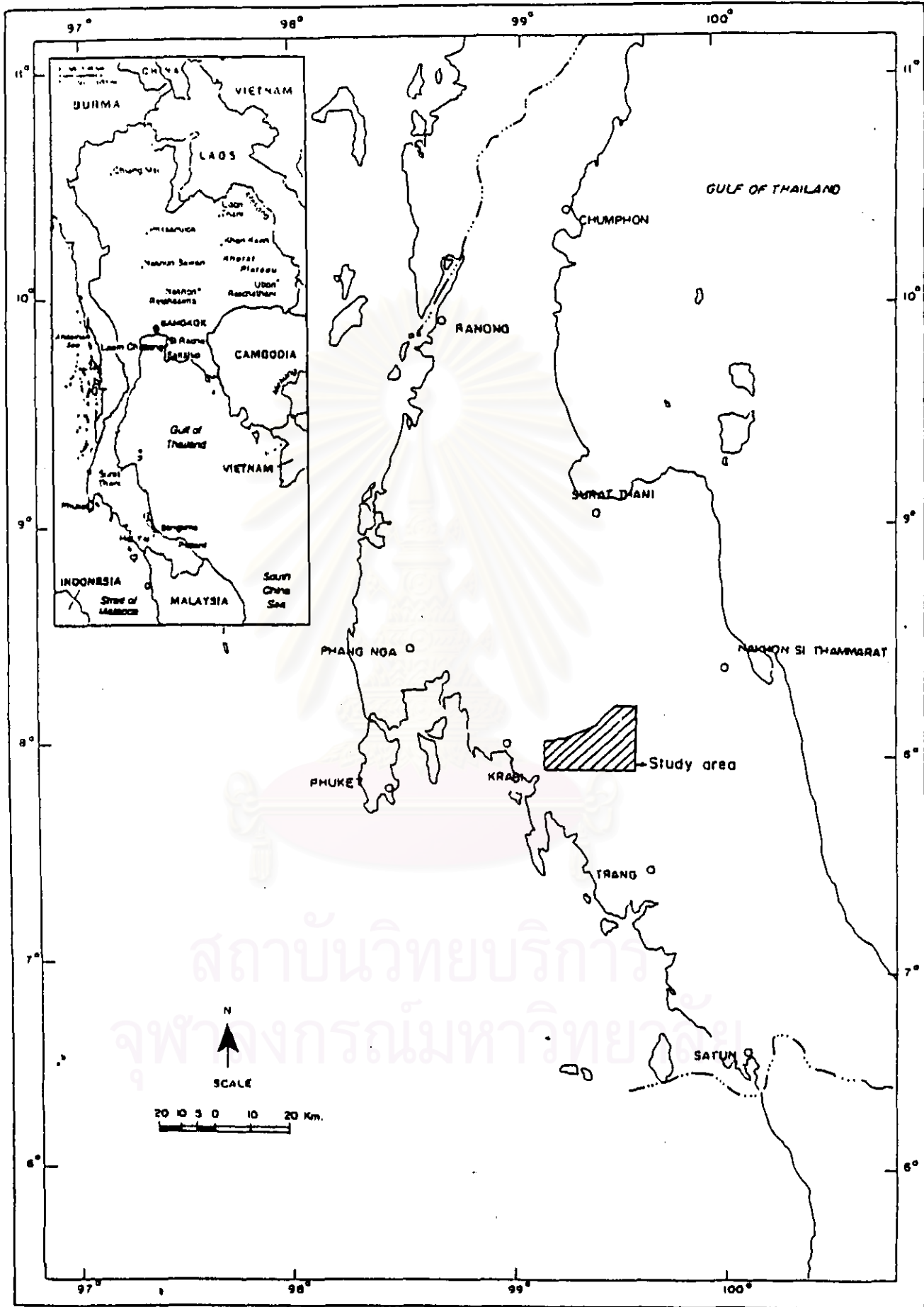


Figure 1.1 Map showing the study area.



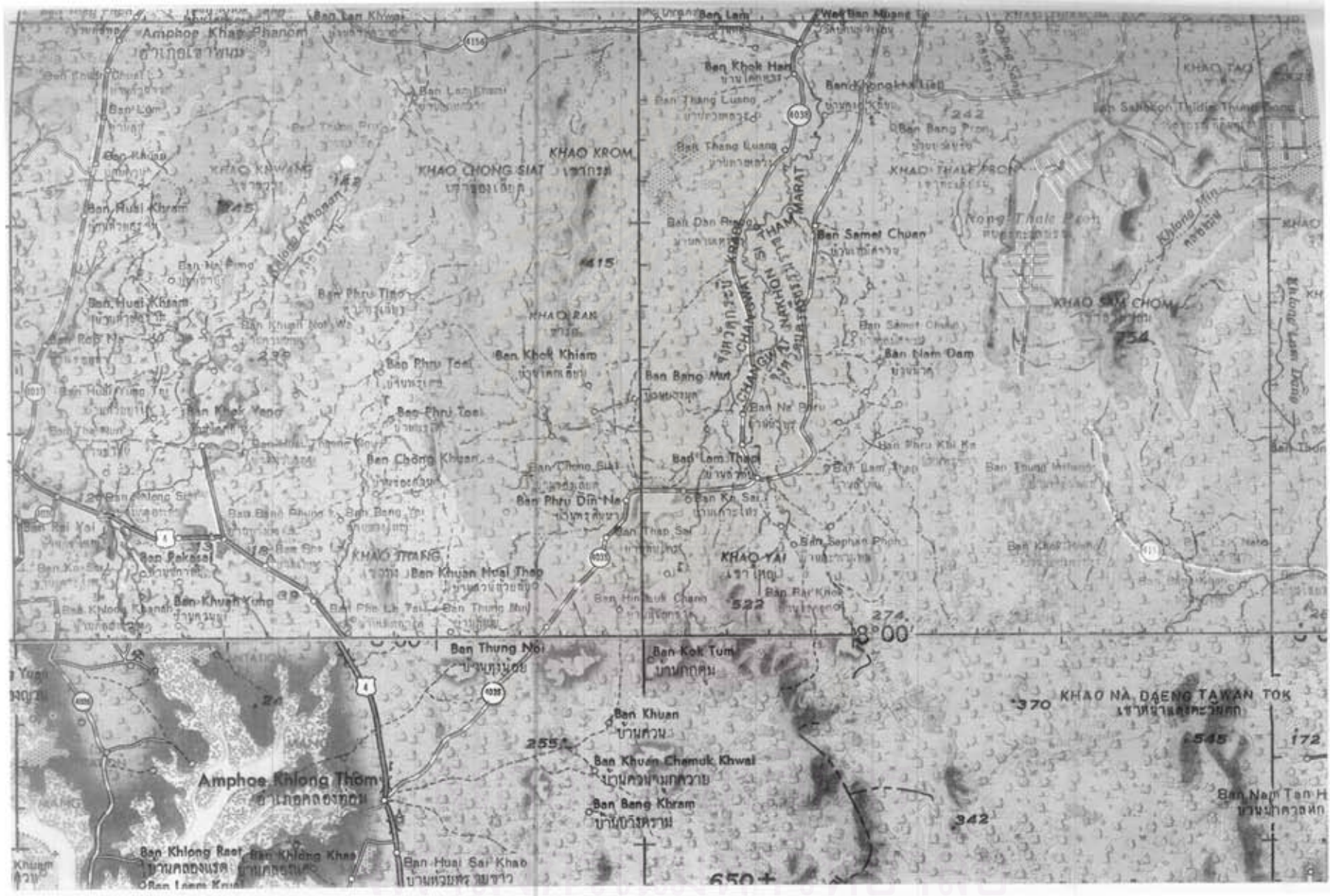


Figure 1.2 The topography of the study area.

part of the area, the drainage pattern irregular lying approximately in the northeast-southwest direction (Figure 1.2).

### 1.2 Objectives of the study

Primarily, the purpose of this study is to conduct the systematic geological mapping and to define the lithostratigraphy of the non-marine Mesozoic rocks distributed in the area of Thung Yai-Khlong Thom, southern Thailand. Additional purpose is to analyse the sedimentary sequences in terms of sedimentary facies and to reconstruct the depositional environment of the sediments concerned.

### 1.3 Study methodology and scope of work

Basically, the existing information on regional geology of the southern part of Thailand are reviewed to serve as a background of the present study. Later on, the study is focussing upon the geological setting of Thung Yai-Khlong Thom and adjacent areas in order to fully understand the geological history, sedimentation model as well as the geological evolution of the area.

In short, the methodology consists of the following steps (Figure 1.3).

#### (1) Planning, Data acquisition and Compilation

The planning involves all activities and time-duration of the study project. It also depends partly on the existing data, and available financial support. Firstly, the geological data of the study area will be collected, reviewed and compiled for further step of work.

#### (2) Desk study, Photo interpretation and Checking the reliability of data

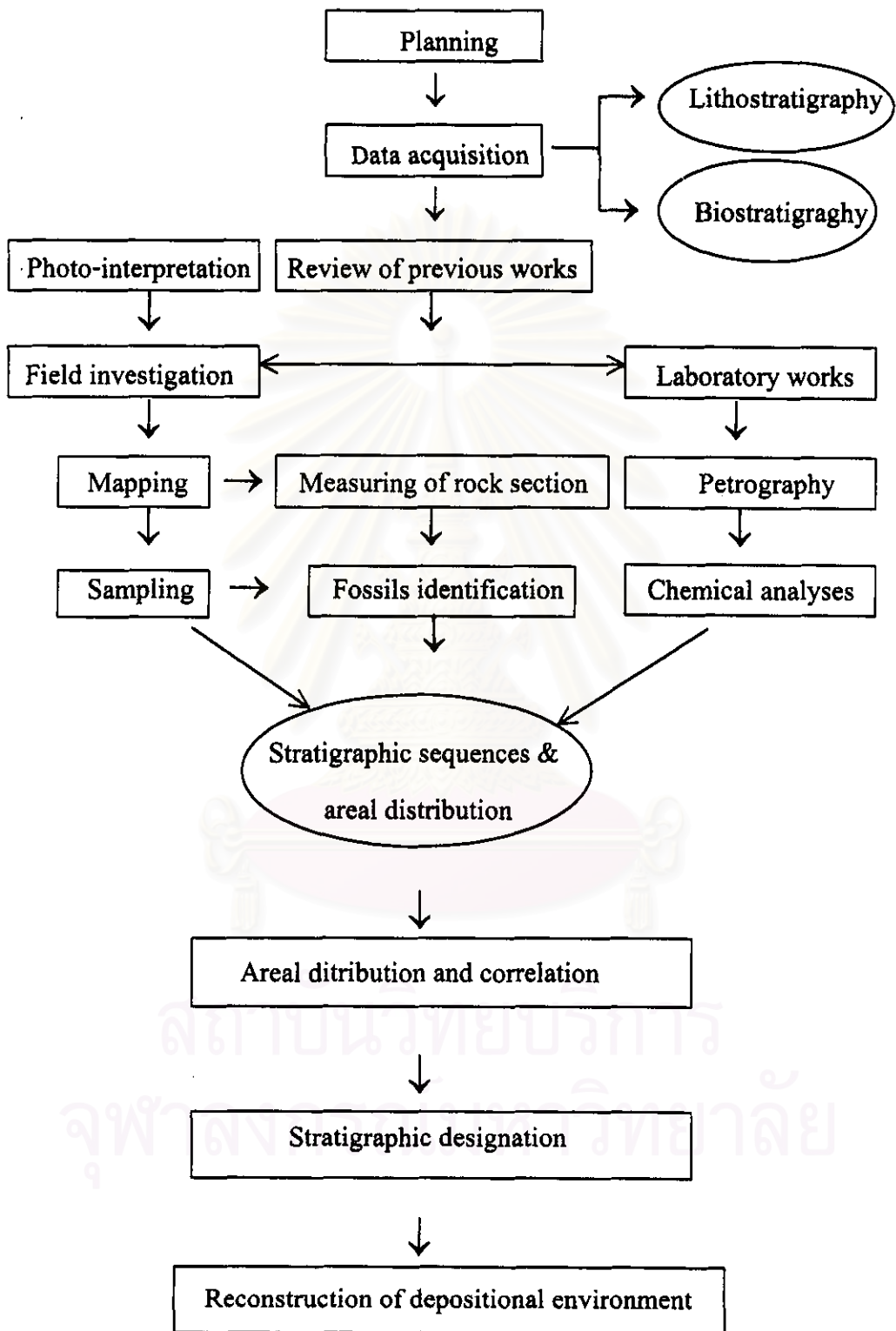


Figure 1.3 The summarized flow chart illustrating the study methodology.

Photo-geological work will be undertaken in the 1:50,000 scale. All data from previous investigation will be integrated with the photogeological study to prepare the initial geological map for further field investigation.

### (3) Field investigation

The field methods is carried out under the systematic mapping. Altogether 17 measured rock sections have been undertaken along Thung Yai-Thung Song, Khlong Thom-Bang Khan and along the coastal area of Laem Ploe of Ban Bo Muang. The representative rock sampling of every unit has been carried out. It is expected that some index fossils will be preserved which can be identified and determined the age of rock. Besides, the appropriate classifications of sedimentary and igneous rocks, as well as textures are determined for the present study ( Pettijohn, 1975; Selly, 1996; Dott,1964; Folk, 1959; Folk,1968; and Streckeisen, 1973).

### 4) Laboratory works

Both petrographic observation and chemical analyses have been undertaken to assist in the identification of selected rock and fossil samples. For the petrographic work, it includes the determinations of 6 rock-slaps, 63 thin-sections, 2 scanning electron micrographs, and 3 X-ray diffractograms. With respect to the chemical analysis, altogether 18 samples are determined for  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{P}_2\text{O}_5$ ,  $\text{MgO}$ ,  $\text{CaO}$ , ignition loss by the wet analysis (classical method) and for As as well as Rb by the Atomic Absorption Spectrophotometry.

### (5) Data analysis and Interpretation

All geological data and related information will be analysed. The result will be evaluated and interpreted. During this stage, additional field investigation will be carried out in order to obtain missing data. Finally, conclusion will be made on the basis of the interpretation of factual data.

### (6) Report writing and Presentation



The report will be prepared in accordance with the objectives of the study. The result of study will be presented as:

- Geological map.
- Stratigraphic designation, and proposed nomenclature.
- Reconstruction of depositional environment.

#### 1.4 Data sources and Previous investigations:

##### Data sources

The studied data have been provided by the Geological Survey Division, the Department of Mineral Resources. The data consist of geological map of Changwat Surat Thani 1:250,000 scale, and Changwat Nakhon Si Thammarat 1:250,000 scale, geological maps 1:50,000 scale of sheets Amphoe Thung Yai (4825 I), Ban Thang Luang (4825 II), Ban Nua Khlong (4825III), Amphoe Ban Na San (4826 I), Amphoe Pra Saeng (4826 II), Ban Bang Pha (4826 III), Ban Krian Sa (4826 IV), Ban Khao Pra Nom (4825 IV), Khao Noi (4824 I), and Amphoe Thung Song (4925 III) with addition of the geological maps of the Khlong Thom and Wang Vi Set areas prepared by geology students of the Department of Geology, Faculty of Science, Chulalongkorn University in 1996 and 1998.

##### Previous investigations

The Mesozoic rocks in peninsular Thailand was first reported by Kobayashi & Tokuyama (1959) from the discovery of Triassic fossils in the southern part of Thailand.

Hayami (1960) studied the bivalve in argillaceous sandstone at Haat Sai Ri, Pak Nam Chumphon of Chumphon and concluded that it is *Eomiodon chumponnesis* sp. of probably Jurassic age.



Javanaphet (1969) designated the Khorat Group for Mesozoic rocks in peninsular Thailand on the geological map, scale 1:1,000,000, of the Department of Mineral Resources.

Garson et al.(1975) reported the sedimentary sequence of sandstone, siltstone, and conglomerate about 400 metres thick unconformably overlying the Rat Buri Limestone.

In 1977, the regional mapping project of the Department of Mineral Resources to produce geological maps on a scale of 1:250,000 was started in southern Thailand. Snansieng et al.(1977) mapped the Mesozoic rocks in one unit. The distribution of these rocks were mostly in the area of Chumphon-Nakhon Si Thammarat and Trang area.

In Songkhla, the marine Triassic sediments were well known in the past. Grant-Mackie et al.(1978) studied some of the strata in Na Thawi and Saba Yoi and introduced an informal lithostratigraphic scheme for different presumably Triassic units overlying Permian limestone or older rocks. Besides, they distinguished 4 lithostratigraphic units in descending order as follows: Sani formation consisting of siltstone, siliceous or non-siliceous fine-grained sandstone, black chert, and fine to medium-grained conglomerate, of totally 4,300 metres thick; Khlong Kon Limestone consisting of light to gray massive limestone of up to 600 metres thick; Chedi Conglomerate consisting of massive quartzose-conglomerate of 250 metres thick; and Suan Chan formation consisting of siltstone interbedded with graded sandstone of 1,700 metres thick. They also believed that the Khlong Kon Limestone was equivalent to the Pha Kan formation of Lampang basin.

At the Na Thawi of Songkhla, along the highway no. 42, the sequence of Triassic had been found in descending order as follows: Lam Long Sandstone consisting of thin-bedded fine-grained sandstone of 3,700 metres thick; Wang Yai

Siltstone consisting of gray laminated sandy siltstone of 3 metres thick; Na Thawi formation consisting of interbedded siltstone and siliceous sandstone with *Daonella* sp. (Middle Carnian age) of 3,000 metres thick (Grant-Mackie et al.,1980).

Udomratn et al.(1981) studied some of the strata of Mesozoic rocks in the peninsular Thailand and distinguished 4 lithostratigraphic units in ascending order as follows:

1. Lowermost unit (M1) consists of interbedding of shale, siltstone, argillaceous limestone and carbonaceous limestone with bivalves and small amount of plant fossils.

2. Lower unit (M2) consists of sandstone, siltstone, and limestone lenses with bivalve fossil.

3. Middle unit (M3) consists of siltstone, sandstone, conglomeratic sandstone and conglomerate interbedded with limestone, dolomitic limestone and dolomite, with rare plant fossil.

4. Upper unit (M4) consists of sandstone and shale.

The rock units form M1-M4 are of Upper Triassic to Lower Cretaceous age.

Asama et al.(1981) studied fossil plants in strata of siltstone, silty sandstone, and fine-grained sandstone, gray to brownish red at the Trang area and identified and described altogether 6 species, as follows:

Filicales

*Gleichenoides gagauensis* Kon'no

*Gleichenoides pantiensis* Kon'no

Bennettitales

*Otozamites gagauensis* Kon'no

*Otozamites* sp.

Coniferales

*Podozamites pahangensis* Asama

*Frenelopsis* sp.

These plant fossils in this Trang area are different from plant fossils of the Huai Hin Lat Formation, Khorat Group (Kon'no and Asama, 1973) but similar to the Gagau Group in Malay Peninsula. The age of these plant fossils are early Early Cretaceous.

The systematic mapping on the scale of 1: 50,000 in southern Thailand started in 1989 by the Geological Survey Division, Department of Mineral Resources. Raksaskulwong et al., 1989 divided the Mesozoic rocks in Thung Yai-Khlong Thom area into 5 formations in ascending order, namely: Sai Bon, Lam Thap, Khlong Min, Sam Chom, and Phun Phin formations. Originally, the Khlong Min formation was the Khlong Min member in Sin Pun formation of Tertiary age. Jumnonthai (pers. comm., 1999) identified the pelecypod in the Khlong Min formation as *Corbula njalindungensis* of Jurassic age.

Zuoqi, 1993 studied the sporepollen assemblage from red beds of peninsular Thailand composing predominantly of gymnosperm pollens (94.46%), some pterophyte spores (5.26%), and rare algae (0.28%). The prevailing gymnosperm genera are *Classopollis* (86.18% of the total amount) and *Dicheiropollis* (4.25%) of Cheirolepidaceae. This sporepollen assemblage was given a Late Jurassic age.

In the Chumphon area, ammonite and bivalves indicative of the Early Bajocian had been found in shaly rock at Khao Lak, about 80 kilometres in the northern part of Chumphon (Meesook and Grant-Mackie, 1994). The Khao Lak Formation consists of interbedded sandstone and shale with cherty limestone.

Meesook and Grant-Mackie (1994) reported that the rocks of the Phra Bat Formation in the Chian Yai and Hua Sai areas of Nakhon Si Thammarat consists of mudstone and sandstone of Toarcian age.

The non-marine Mesozoic sequence exposed in the middle part of Thai peninsula was proposed as the Trang Group (Raksaskulwong, 1994) particularly in the Chumphon to Trang area. The group unconformably overlies the marine Triassic rocks with basal conglomerate in many localities around Thung Yai and a hill beside a road, 10 kilometres north of Chumphon.

Raksaskulwong (1994) divided the Trang Group into 4 formations in ascending order as, Chumphon red beds formation, Khlong Min formation, Khao Sam Chom formation and Phun Phin formation, respectively.

The Chumphon red beds formation consists mainly of brownish red to light brown quartzitic and arkosic sandstones interbedded with siltstone and gray mudstone with plant remains and pelecypods. The rocks were believed to be deposited in the transitional marine environment. The Khlong Min formation composes of mudstone, fossiliferous mudstone and oil shale. Fossils of both vertebrates and invertebrates are abundant in this formation. These fossil assemblages reflect the lacustrine environment. The Khao Sam Chom formation predominantly composes of conglomerate and poorly cemented coarse-grained sandstone of alluvial fan and braided stream origins. The Phun Phin formation composes mainly of brownish red, fine-grained sandstone and siltstone. Trough and planar cross-beddings reflecting braided stream environment are very common in this formation.

Trace fossils of *Thalassinoides*, bivalve of *Modiolus* sp., fern-like leaves and small lenses of bituminous jets, in paralic massive fine-grained sandstone of Chumphon red beds formation and vertebrate fossils of turtle plate, crocodile teeth, amphibians, bivalves in muddy limestone of Khlong Min formation are considered to be equivalent to the lower part of the Khorat Group in northeastern Thailand and to some parts of the Gagau Group in Malay Peninsula.



The lithostratigraphy of the Trang Group (Raksaskulwong, 1994) is summarized and presented in Table 2.4.

Buffetaut et al.(1994) reported the discoveries of vertebrate fossils in Mesozoic non-marine rocks at several localities in the peninsular Thailand. The main localities are Khao Nin Pu Sri (referred to the Middle Jurassic on the basis of palynomorphs) in Trang, and Ban Mab Ching (referred to the Middle Jurassic on the basis of charophytes) in Nakhon Si Thammarat. The fauna includes hybodont shark, *Lepidotes*-like actinopterygians, lungfishes, temnospondyl amphibians, mesosuchian crocodylians, and cryptodiran turtles. The assemblages from Khao Nin Pu Sri and Ban Mab Ching are in agreement with the Jurassic age as indicated by other fossils.

In 1998, students from the Department of Geology, Chulalongkorn University conducted the field work in the Wang Vi Set area and divided the rocks in this area into 7 formations in ascending order as Khok Chak Phra, Khuan Khwang, Lang Khao, Khuan Sam Nak, Khao Yai and Na Daeng formations, respectively. The whole sequence is believed to be of Upper Triassic to Lower Cretaceous in age.