



## CHAPTER I

### INTRODUCTION

The Northeastern, known as the Khorat Plateau, one of the main physiographic province of Thailand, is a block-like structural and geomorphological unit that covers about one-third of the total area of the country. It lies between the latitude of  $14^{\circ}$  and  $19^{\circ}$  north and the longitude of  $101^{\circ}$  and  $106^{\circ}$  east. Physiographically, the Khorat Plateau can be broadly divided into three main parts, namely, the Phu Phan range which bounds the Udon-Sakhon Nakhon Basin in the north and the Khorat-Ubol Basin in the south. The area consists of erosional and depositional landforms. The general topography is gently dipping eastwards and mainly covered with surficial deposits. The escarpments and long ranges of mountains mark the boundary on the west and the south. The northern and western part of the region is bounded by the Khong River.

Formerly, the region was considered to be low in economic mineral potential in comparison with other parts of the country. Therefore, geological investigations had not been carried out in a satisfactory scale. Since 1955, the Department of Mineral Resources (DMR.) had launched the groundwater exploration schemes and consequently

found rock salt deposits in many places of the region. This, perhaps, gives rise to the golden period of geological mapping and economic mineral explorations later on.

At present, remote sensing techniques are applied, modified, and adopted as essential tools for many development purposes such as for natural resources study and management, environmental management and control, civil engineering practice, and agricultural study and planning, etc. Remote sensing data - including various types of aerial photographs, satellite imageries, and other kinds of remotely sensed data - can provide significantly the geological informations for mapping purpose. The quite interesting and promising application of the remote sensing techniques is to utilize them for the geological mapping and planning of the Northeastern Thailand.

A huge territory of the Northeast is mainly blanketed by surficial materials. Limitation of good rock exposures in the region gives rise to geological ground survey problems. These problems include the consumption of very long period of time for mapping process and that budget insufficiency to operate the programme. Besides, there are also a limited number of qualified professional field geologists to carry out the mapping project. Geological mapping by remote sensing techniques will certainly alleviate these problems and definitely believed

to be a good solution.

### 1.1 Objectives.

The existing development projects and research programmes, particularly economic and industrial mineral resources development together with the feasibility of the natural resources development potentials, undertaken by government agencies and private organizations within the selected area would be highly facilitated should baseline information on geology of the area is readily available. Therefore, the overall objectives of this study are as follows :-

1.1.1 to carry out a geological mapping of the area as a pilot geological mapping project by using remote sensing image interpretation.

1.1.2 to collect and select the available existing geological mapping techniques, then modify and develop an appropriate mapping scheme to suit rudimentary requirements for this area. Remote sensing data and techniques together with terrain analysis approaches are utilized in this study.

1.1.3 to collect, compile and present the fundamental geological information of the investigation area in a properly designed format. The mapping scheme used and / or developed in this study may be adopted for use in other areas of the Northeast.

1.1.4 to provide preliminary geological information of the area for future planning and development. For examples, future landuse planning, natural resources, particulary Quaternary resources, planning and development.

The ultimate goal is to produce a geological map of the selected area. It is expected that the developed mapping scheme would hopefully solve and alleviate fundamental geological survey problems of the region and thus increasing benefits and would be important for the investigation and development plannings of regional mineral resources.

## 1.2 Study Area.

The study area is located at nearly central part of the Northeastern Thailand. It is bounded by latitude  $16^{\circ} 10'$  to  $16^{\circ} 35'$  north and longitude  $102^{\circ} 30'$  to  $103^{\circ} 15'$  east with an area of approximately 3,680 square kilometers. It occupies mainly the areas of Changwat Khon Kaen and some parts of Changwat Maha Sarakham and Kalasin (Figure 1.1).

### 1.2.1 Physiography.

The general physiography of the study area can be broadly recognized and subdivided into three main physiographic groups: elongated hilly terrain, undulating - rolling terrain and low land alluvial plain as shown in

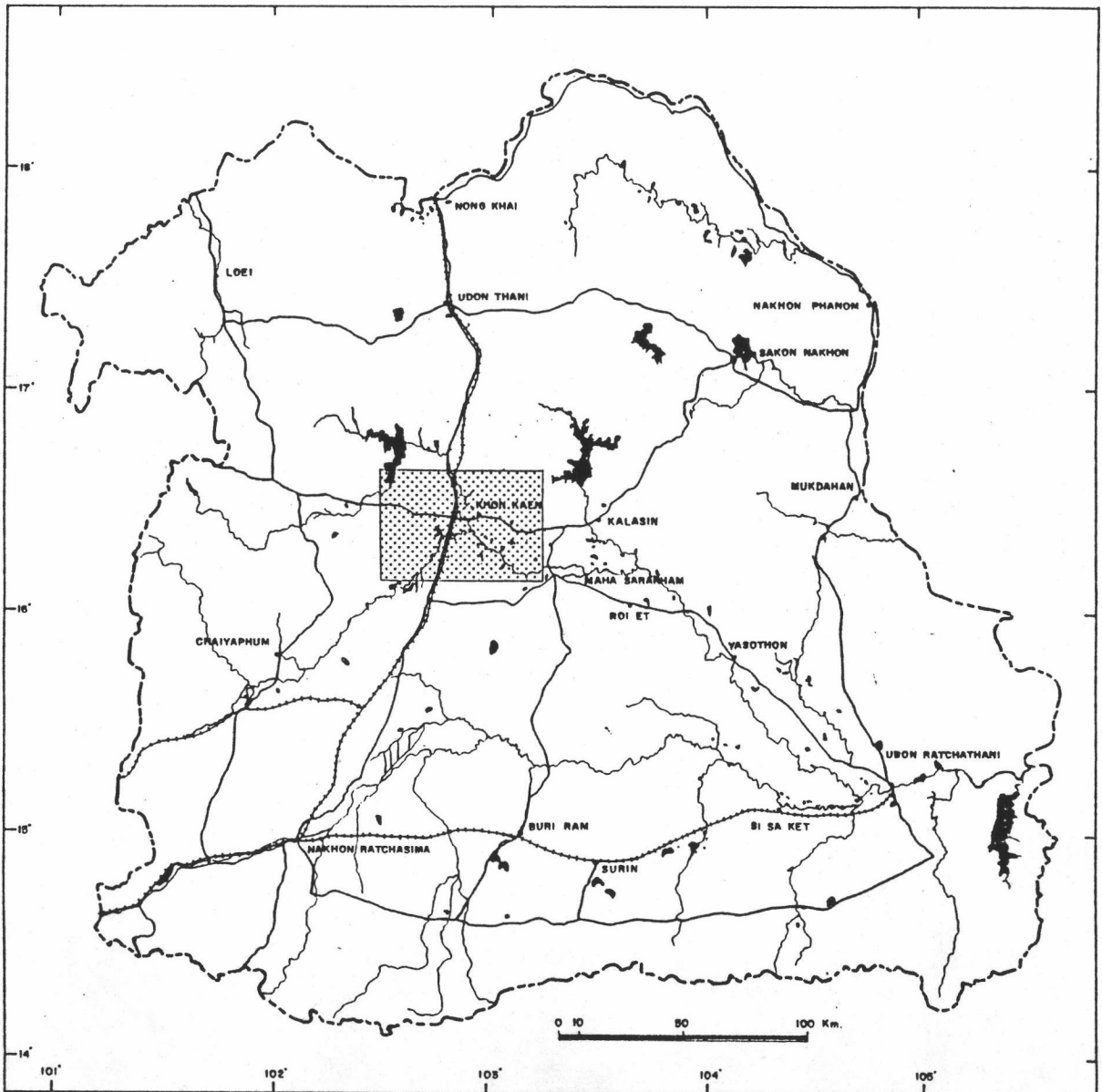


Figure 1.1 Map showing location of the study area.

	Explanation		
	• Changwat	—+—+— Railroad	Reservoir
— Highway	River	--- Boundary of the Northeast	
	THE STUDY AREA		

Photo-interpretation for Geological Mapping of Changwat Khon Kaen and Adjacent Areas.

Somyot Hokjaroen  
 Dept. of Geology, Graduate School,  
 Chulalongkorn University, 1986.



Figure 1.2 (Hokjaroen and Supajanya, 1982). These are classified according to the major characteristics of topography described for the Southern Khorat Plateau.

The elongated hilly terrain, covering about 10 percent of the whole study area, extends only along the western part in the forms of long ridges and broad valleys. They are more or less trend in north-northeast direction comprised of Phu Phan Kham in the north , Phu Meng in the south which contain narrow, small ridges and valleys between them. The highest elevation of this terrain is 642 metres at Phu Meng and general elevation is 230 to 250 metres above mean sea level (AMS.).

The undulating - rolling terrain, which is the main physiographic unit covering about 60 percent of the study area, has the surface elevation between 160 to 230 metres AMS. General physiographic expressions are more or less monotonous plain to gently undulating terrain (mounds and low-rolling hills).

The low land alluvial plain shows long and broad zone within the previously described terrains. Its major part is drained and activated by Mae Nam Chi, Lam Nam Phong and their numerous tributaries. Both river systems traverse the central study area and join together at Ban Kui Chuak, Amphoe Muang Changwat Khon Kaen before flowing eastward across the area. Natural levees, back swamp

deposits and many of oxbow lakes (or 'Kud') along the river courses are formed. Besides, many of large swamps or other depression features can be found within the terrain. The elevation of this group ranges between 145 to 160 meters AMS.

### 1.2.2 Climate.

According to the Agroclimatological Map (Eelaart, 1972), the study area belongs to tropical savanna climate and low rainfall, transitional zone. This means that it benefits the rain from one of the two monsoon seasons. It receives approximately 80 to 250 mm. of monthly rainfall from the southwest monsoon during May to October of wet season. From November to January, the area is in the period of dry and cold season, mainly affected by the other monsoon which comes from the northeast. During February to May, the weather is hot and dry with occasionally rainfalls due to because of the tropical cyclone. The quantity of rainfall, temperature, evaporation and relative humidity of the study area are averaged using the data obtained from the Meteorological Department and summarized monthly as shown in Figure 1.3.

## 1.3 Geological Setting.

### 1.3.1 Physiographic and Geological Setting of the Khorat Plateau.

The Khorat Plateau covers a large area of about



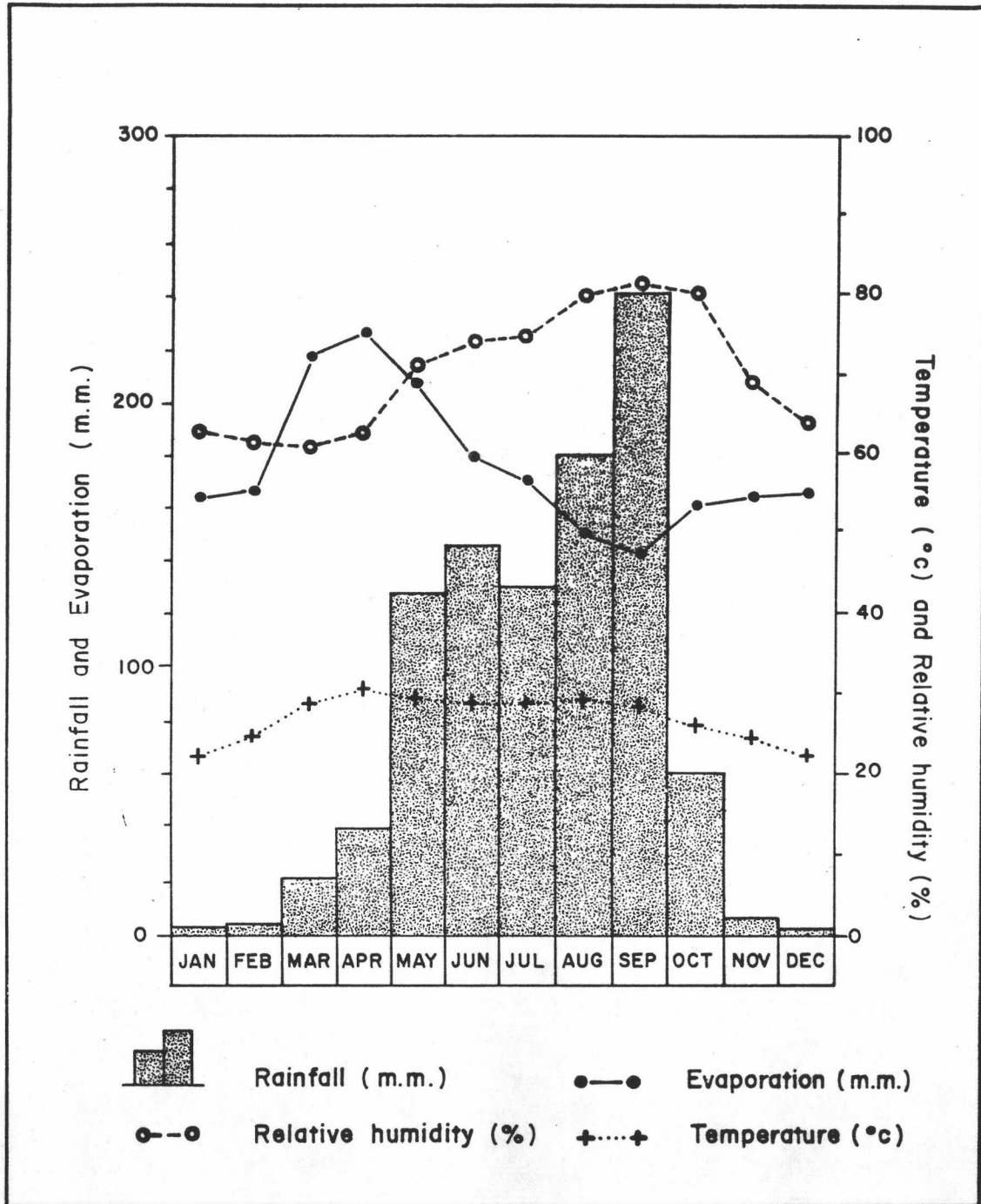


Figure 1.3 The 30-year average rainfall, evaporation, temperature and relative humidity of Changwat Khon Kaen (1951-1980), constructed from Meteorological Department, 1984.

170,000 square kilometers. The plateau comprises of two large broad basins, namely, the northern Udon-Sakon Nakhon Basin which covers approximately 17,000 square kilometers, and the relatively larger Khorat-Ubon Basin in the south covering an area of about 33,000 square kilometers. These two basins are separated by the northwest - southeast trending of Phu Phan Mountain Ranges.

Generally, the Khorat Plateau is a very distinctive physiographic region in Thailand with its simple geology, geological structure and topography. The plateau is believed to be the results of epeirogenic movements as warping and block faulting during Mid-Tertiary and probably Quaternary periods (Thiramongkol, 1978). It is elevated with respect to the Central Plain but also bounded in the southeast, the south and the west by a steep and in places mountainous, outward facing escarpment. Its regional topography is undulating to flat and dotted by small hills and mostly of the region is covered by old and young surficial deposits of various origins.

The Khorat Plateau is drained almost entirely by two river systems, the Mun and the Chi, which flow from west across the southern basin to Khong River. In the northern part of the region, there are small tributaries flowing directly into Khong River. Over the general land area, streams are braided and occasionally discontinuous

in the lowlands and ephemeral in the upland.

Geologically, the Khorat Plateau is a large warping sedimentary and / or tectonic basin which is mainly underlain by continental Mesozoic sediments. The basin is separated by the tectonically undulating Phu Phan Mountain Range (or Phu Phan Anticlinorium) into the northern Udon-Sakon Nakhon Basin and extending to Khorat-Ubol Basin in the south (Figure 1.4).

The thick sedimentary sequences underlying the Khorat Plateau are mainly the rocks of the Khorat Group (Ward and Bunnag, 1964). Numerous workers have attempted to subdivide the Khorat Group into several formations, and these stratigraphical subdivisions are summarized and presented in Table 1.1. The Khorat Group consists almost entirely of red bed originating from shallow water deposits. The upper part of the sequences contains very thick evaporite deposits. The minimum thickness of sedimentary sequences of the Khorat Group is estimated to be 2,384 metres. Rocks of the Khorat Group are generally flat lying on gently dipping conglomerate, sandstone, shale, siltstone and evaporites.

Overlying the Khorat Group are unconsolidated clay, sand and gravel of Quaternary age in many areas of the Khorat Plateau. These deposits are fluvial, flood plain and terrace in origin. Besides, a thin veneers of reddish lateritic soil, generally 1-3 metres thick,

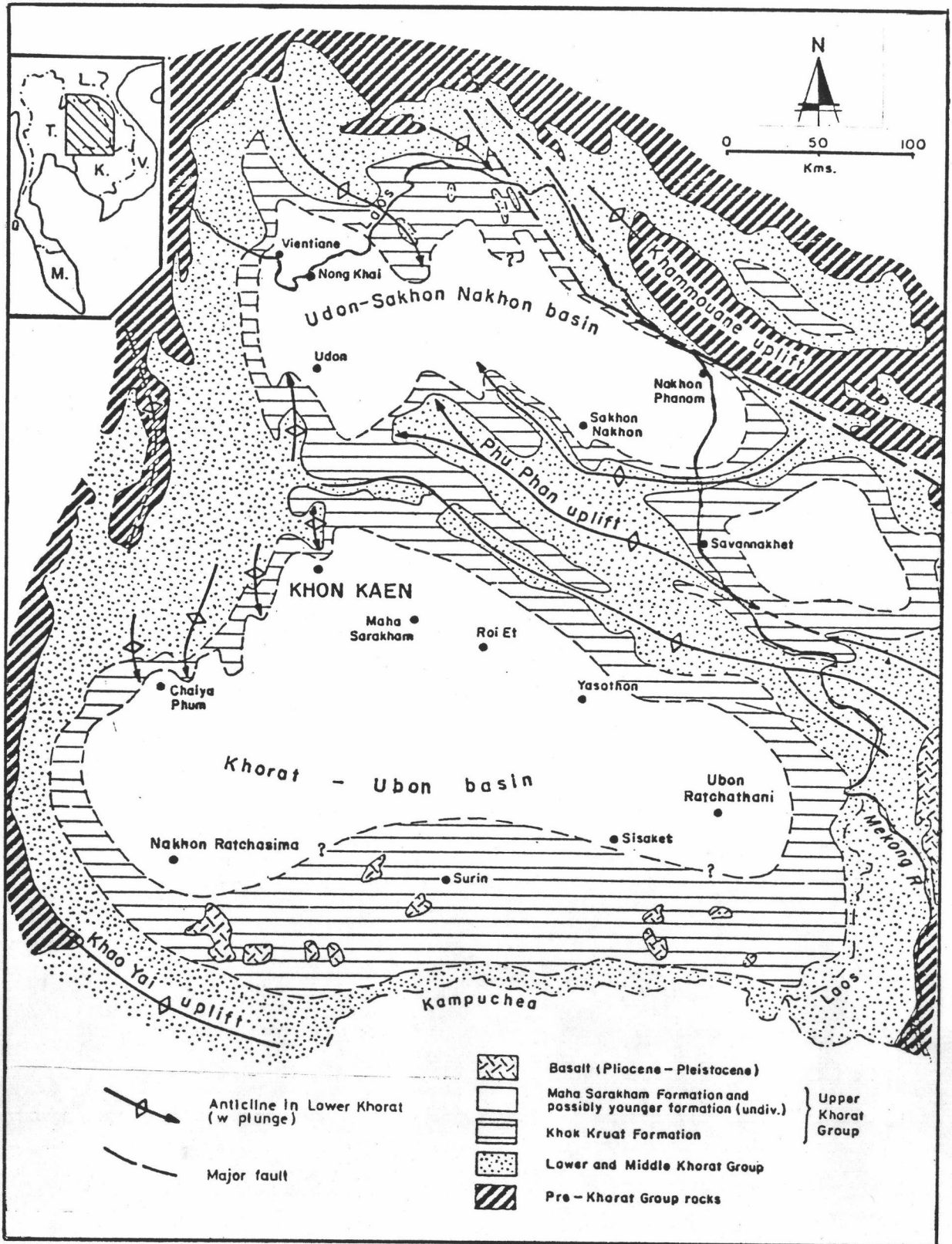


Figure 1.4 Generalized geological map of Northeast Thailand and neighbouring areas of Laos (after Japakasetr and Workman, 1981).

Table 1.1. Stratigraphic subdivision of the Khorat Group (After Yumuang, 1983).

La Moreaux and others (1959)	Ward and Bunnag (1964)	Iwai and others (1968)	Borax and Steward (1965)	Iwai and others (1975)	Workman (1977)	Dept. Min. Resources (1982)
Unnamed	Khok Kruat Fm.	Lom Sak Fm.	Upper	Lom Sak Fm.	Salt (Maha Sarakham) Fm.	Maha Sarakham Fm.
		Ban Na Yo Fm.		Ban Na Yo Fm. S.STR ? NamPhung Fm. S1	Ban Na Yo (Khok Kruat) Fm.	Khok Kruat Fm.
Phu Phan member	Phu Phan Fm.	Phu Phan Fm.	Upper Resistant Sandstone	Phu Phan Fm.	Phra Wihan member	Phu Phan Fm.
Phra Wihan Fm.	Sao Khua Fm. Phra Wihan Fm.	Phra Wihan Fm.	Middle Intermediate member Lower Resistant Sandstone	Phra Wihan Fm.	Sao Kua member Lower Phra Wihan member	Sao Kua Fm. Phra Wihan Fm.
Phu Kradung Fm.	Phu Kradung Fm.	Phu Kradung Fm.	Lower Lake bed (?)	Phu Kradung Fm.	Upper Phu Kradung member	Phu Kradung Fm.
	Nam Phong Fm.	Huai Hin Lat Fm.	Locally Basal conglomerate	Nam Pha Huai Hin Lat Fm.	Nam Phong member	Nam Phong Fm. Huai Hin Lat Fm.
KHORAT SERIES						
KHORAT GROUP						
KHORAT GROUP						
KHORAT GROUP						

extends over considerable areas in northeastern Thailand. In some parts, well-developed laterite has been observed.

Igneous rocks in northeastern Thailand include Triassic-Jurassic and Cretaceous granites, Permo-Triassic andesites and rhyolites, Cretaceous andesites, Tertiary andesites and rhyolites and Quaternary basalts. The majority of these exposures are situated towards the west and south margins of the Khorat Plateau. Besides, remnants of basalt flows overlying the Khorat Group are exposed in the southern part of the Khorat Plateau as hills rising above floor of the plateau. By far the commonest type of basalt is one containing olivine and pyroxene. The eruption of basalt was believed to be essentially of a Quaternary phenomenon.

#### 1.3.2 Geological Setting of the Study Area.

The geology of the study area is fairly simple as shown in Figure 1.5. It is mainly composed of the continental Mesozoic sedimentary rocks, Khorat Group, and the Quaternary deposits. The Khorat Group rests unconformably on the older rocks, generally of Paleozoic age (Sattayarak, 1983) which are not cropped out elsewhere within the study area.

On the western part of the area, it is bounded by a broad hill range in north-northeast direction. This range is all composed of the Mesozoic sedimentary rocks which uplifting is theorized to have taken place in Late

Tertiary to Early Pleistocene time (Bunopas and Vella, 1983). The western part of this range is composed of Nam Phong and Phu Kradung Formations. The broad - hill range, which is supported by the resistant arenaceous rock of Pra Wihan-Phu Phan Formations and non-resistant arenaceous rock of Sao Khua-Khok Kruat Formations, is represented by elongated hills and broad valleys. The eastern part of this range, the north and the south of the area, which mostly represented as undulating topography, is belonged to Maha Sarakham Formation while the others are Quaternary deposits. All lithologic descriptions of these formations are summarized as shown in the explanation of Figure 1.5.

The main structural features are broad anticlinal and synclinal folds with their axes trending in N-NW to S-SE directions and plunging to the S-SE direction (Figure C-4). These structures lying in the north of the study area which caused the underlying formation warping. At the western margin of the area which is the east flank of Phu Meng Anticline, the rocks show the homoclinal structure in north-south trending with gently dipping eastward. Besides, at the south-west of the area an anticlinal fold with axis trending NW-SE direction is clearly observed.

#### 1.4 Previous Works.

##### 1.4.1 Regional Geologic Mapping of the Northeast.

012259







Before the last three decades, this region was considered to be a mineral-barren plateau, except for the northwest corner of the region where there are some unexploited economic mineral deposits. Though covering huge area, the resources development has been carried out only in a little scale. The limitation to the exploitation of the land resources here may be due to its uniform underlied rocks, physiography which is mainly flat and undulating terrain together with climatic conditions. Therefore, few geological and related resource maps of this area have been produced comparing to the other parts of Thailand where the resources have continuously been searched by numerous organizations.

However, it has to be noted that the northeastern part of Thailand has long been a subject of interest to western countries. A continuous series of good and fairly detailed 1:500,000 scale geological maps had been published by the former French Service Geologique de l'Indochine since 1935. In addition, these maps had been reestablished and republished again by the National Geographical Service of Viet Nam in the years 1961-1963. The maps cover the boundary areas of Laos, Cambodia and the Khorat Plateau. Besides, they can be profitably used in connection with interpretation and more detailed studies of the geological and geomorphological features of the Northeast of Thailand as well.

In 1955, the Department of Mineral Resources (DMR.) has launched the groundwater exploration programme to meet the demand for water in the Northeast. This marked the good beginning of many geological and other resources development schemes. It revealed that some of the groundwater drilling wells have penetrated the rock salt layers. This led to the geologic hypothetical thinking and mapping for the extension of salt layers as well as other economic minerals in the region. As a result, many types of geological maps are presented both in general scale and some in detailed for various aspects.

As a sequence of the groundwater exploration programmes, the first and reasonably complete geological map of the northeastern Thailand (1:750,000) was established and published in the Ground Water Bulletin No.2, by DMR. (Haworth, et.al., 1966). It presents a good sequence of rock formations underlain Khorat Plateau and parts of the Loei, Petchabun, Lopburi, Saraburi and Prachinburi Provinces (the area about 200,000 square kilometers). This map, however, fails to give a fair picture of the Quaternary deposits.

In 1964, Ward and Bunnag studied the stratigraphy of the Mesozoic Khorat Group in the northeastern Thailand based on five systematic measuring sections. They divided the Khorat Group into 7 formations, namely, Nam Phong, Phu Kradung, Phra Wihan, Sao Khua, Phu Phan, Khok Kruat Formation and the Unnamed Rock. These

formations are usually referred and mainly used for the basic mapping by the junior geologists who have to deal with the Mesozoic rocks, especially in the northeast of Thailand. This study, however, illustrates no geological map of the area except for the studies of the 5 measured sections in detailed.

In 1969, the 1:1,000,000 scale of "Geological Map of Thailand" was firstly published by DMR. (Javanaphet, 1969). The northeastern part of this map shows three main stratigraphic successions : Upper Paleozoic, in the west and northwest regions, Mesozoic covers the main country; and Cenozoic overlies only some parts of the region. It should be stated that the three main aforementioned successions were later reviewed further subdivided and corrected on the basis of up-to-date information by numerous workers. This was carried out under a systematic programme of regional mapping by the staff of the Geological Survey Division of DMR. Finally, the unpublished "Geological Map of Northeastern Thailand" with 1:500,000 scale was compiled in 1979 by Sattayarak and Suteetorn. This map, in addition, is now used as a base map for compiling the recent "Geological Map of Thailand" with 1:1,000,000 scale by DMR. (Lumjuan and Lovacharasupaporn, 1984).

The 1:2,500,000 scale of "Soil Map of Thailand" was published by F.A.O. and the Soil Survey Division of the Land Development Department in 1972. The map shows

respectively the general distribution and nature of soils in Thailand and the country's main landform as related to the soil formation (Moormann and Rojanasoonthon, 1972).

Besides, the northeastern of Thailand has been studied and presented in many forms and various aspects by Workman. The initial one of his works was the review of geology of Laos, Cambodia, South Viet Nam and the eastern part of Thailand. This work was reported and illustrated in 1972. Some parts of this report were further studied in a specific aspect and reviewed as "Tectonic evolution of Indochina" in 1975. The year the 1:250,000 scale of photogeological reconnaissance map and the 1:1,000,000 scale of structural map of the Khorat Plateau were established. They not only show a photogeological interpretation and summary of selected well-log data of this region, but also the basic geological structures and morphotectonic units of the Mesozoic Formations representing the bedrock series. In addition, the series of these works were compiled into "Geology of Laos, Cambodia, South Viet Nam and the eastern part of Thailand", which was presented in 1977. Furthermore, in 1981, he presented a report and maps showing the correlation between "the Khorat Group" of Thailand and "the Indosinias" of Laos. in "the study of strata in southern Laos equivalent to the Khorat Group of Thailand using satellite imagery"

#### 1.4.2 Geological Mapping in the Neighbourhood of the Study Area.

At the study area, Chonglakmani and others(1979) presented the preliminary geologic survey and Geologic Map of Changwat Khon Kaen (unpublished) in a form of 1:250,000 scale. They divided the Mesozoic Khorat Group into 6 formations, namely, Phu Kradung, Phra Wihan, Sao Khua, Phu Phan, Khok Kruat and Maha Sarakham Formation. They also divided Quaternary deposits into 2 units, namely, Terrace gravel and Alluvium (Figure C-1).

Boonsener(1977, 1980) reported that most of the covering surface sediments of the area was the eolian deposits. This conclusion is based on their morphology, grain size analysis and some certain physical properties of those sediments. In addition, Boonsener and Tassanasorn (1983) reported the geomorphology of Quaternary deposits in Khon Kaen Province and divided them into 5 geomorphologic units, namely, high terrace, low terrace, floodplain, sand rises and lakes, and swamps.

Eiumnoh and Kheowruenrome(1981) used the Landsat imagery for geomorphological mapping in some area of the northeast region. They interpreted and divided the landforms of this area into 8 units, namely, fragments of structural surfaces(dip slope), escarpment, fragments of pediment fashioned by erosion and denudation(active), high terrace, middle terrace, low terrace, plains formed

by proluvial accumulation and river built plains (Figure C-2). Furthermore, Vijarnson compiled and established a recent 1:1,000,000 scale of " Soil Map of Thailand " in 1982. According to the map 8 soil mapping units, which occupied within the study area, were classified and grouped as presented in Figure C-3.

Nevertheless, it has to be noted that, the other sources of previous geological information are available from local offices of petroleum explorations, groundwater explorations, engineering geology, economic mineral explorations, soil surveys and even paleomagnetic study. Recently, Sattayarak (1983), reviewed the continental Mesozoic stratigraphy of Thailand which especially concerned about the Khorat Group (Appendix D ). In the author's opinion, this review is the most update knowledge of the Khorat rocks and their equivalents. In the review, Mesozoic environments for each formation are also summarized.

### 1.5 Data Sources.

The primary data source for this study is 169 frames of black and white aerial photographs of approximately 1:40,000 scale, in the format of 23 x 23 cm. which produced by the Royal Thai Survey Department. Those aerial photographs applied in the study area are listed in Table 1.2. The data were taken by World Wide Surveys Incoporation since 1953. Though the photographs

Table 1.2 Selected aerial photographs (WWS.Project) for the study.

Area	Sheet	Roll	Strip	Photo No.	Date
4	6	117	18	20456 - 20468	13-04-54
		116	18	20188 - 20200	07-04-54
		58	19	8786 - 8798	31-12-54
		58	20	8889 - 8901	31-12-53
		75	21	12273 - 12285	15-01-54
		76	22	12371 - 12383	15-01-54
		76	23	12409 - 12421	15-01-54
		76	24	12504 - 12516	15-01-54
4	7	86	25	14486 - 14498	01-02-54
		86	26	14584 - 14596	01-02-54
		88	27	14859 - 14871	02-02-54
		88	28	14968 - 14980	02-02-54
		90	29	15199 - 15211	03-02-54



are too small in scale to permit detailed interpretation and too old to give the correct picture of the present landuse conditions, but for the purpose of geologic mapping, it is good quality in terms of image sharpness, greytone contrast, less cloud cover and distortion. This, however, can be observed comparatively to the modern aerial photographs, either those taken in the VAP.61 Project (1965-1967) or the NS. 3 Project (1975), which are illustrated in Table 1.3. Beside, the photo index of Priority Area 4, Sheet 6 and Sheet 7 (Figure B-1) with approximately 1:240,000 scale is mainly applied simultaneously in the initial stage of the study.

In addition, Landsat-3 imageries (MSS., RBV. and FCC. imageries) scene : Thailand I.D. 3-5, recorded in October 7, 1979 are selected for the preliminary survey and structural analysis. Those MSS. and RBV. imageries are illustrated in Figures B-2 and B-3 respectively. Generally, the capability of Landsat imagery in aid of geological mapping rely on the degree of manifestation of elements that represent topography, drainage, vegetation and land use pattern in the image. Multi-dates and Multi-bands of Landsat imagery path 137 and row 49 (Thai I.D. no. 3-5) which covered the study area are examined. According to imagery quality and contrast, those imageries recorded in January, March and October of scale 1:1,000,000 are selected for detailed study. The selected imageries show variation of humidity existing in

the area for each date. The observation indicates that the imageries of band 5 and band 7 recorded in October 7, 1979, show the best quality, thus, they are the most suitable images for geological interpretation of the study area. Black and white prints of these two bands of scale 1:250,000 are used in collaboration with diapositive of false color composite for detailed interpretation.

The other available and relevant data sources were examined and used as supporting data for the study, such as topographic map, geological map, geomorphological map, photolineaments and foldings map, soil map, hydrogeological map, subsurface map and the existing literatures concerned. Some of informations mentioned are illustrated in Appendix C. The detailed of each available data for the study are summarized and shown in Table 1.4. Moreover, before final interpretation and compilation, spot field investigations of selected areas were employed to get the most accuracy of the result.

Table 1.3 Characteristics comparison of the available existing aerial photographs within the study area.

Photo Project Characteristics	WWS.	VAP. 61	N.S.3
<b>General Informations</b>			
Data sources	RTSD	RTSD	RTSD
Film type	panchromatic	panchromatic	panchromatic
Format (cm x cm)	23 x 23	23 x 23	23 x 23
Scale (approx.)	1:40,000	1:60,000	1:15,000
Photo date	1953 - 1954	1967	1967
Handling (with approx. scale)	photo index (1:240,000)	flight line (1:50,000)	flight line (1:50,000)
<b>Image Properties</b>			
Contrast	high	medium	high
Brightness (photo tone)	good	fair	excellent
Sharpness (photo texture)	excellent	fair	excellent
Distortion (photo tilting)	little	moderate	little
% of cloud cover	0 - 2 %	0 - 5 %	0 - 5 %
Geological data	suit for medium scale	suit for small scale	suit for large scale

Table 1.4 Selected appropriate data for the study.

Data	Date	Scale	Total	Data Sources	Purposes
WMS. Aerial Photograph (B&W)	1953-1954	1:40,000	169	Royal Thai Survey Department	Interpretation & field investigation
WMS. Photo Index	1954	1:240,000	2	"	Planning and preliminary study
Topographic Map (Series L7017)	1969-1983	1:50,000	9	"	Base map and field investigation
Topographic Map (Series 1501S)	1983	1:250,000	1	"	Presentation and field investigation
Landsat-3 Imagery (MSS., B&W)	07-10-1979	1:250,000	1	Remote Sensing Division, NRCT.	Interpretation & field investigation
		1:500,000	1	"	Planning and preliminary study
		1:1,000,000	6	"	"
Landsat-3 Imagery (RBV., B&W)	07-10-1979	1:250,000	4	"	"
Landsat-3 Imagery (FCC)	17-01-1976	1:1,000,000	1	"	"
	07-10-1979	1:1,000,000	1	"	"
	05-04-1984	1:1,000,000	1	"	"
Geological Map	1979	1:250,000	1	Dept. of Mineral Resources	Supporting data
Geological Map	1984	1:500,000	1	"	"
Hydrological Map	1983	1:1,000,000	1	"	"
Photo Lineament & Folding Map	1981	1:1,000,000	1	"	"
Geomorphological Map	1984	1:1,000,000	1	Dept. of Land Development	"
Soils Map	1984	1:500,000	1	"	"
Geomorphological Map	1982	1:250,000	1	Kasetsart University	"
Subsurface Map	1983	1:25,000	1	Khon Kaen University	"