

CHAPTER III

RESULTS AND FINDINGS

3.1 General.

Information related to geological mapping is organized and compiled according to the procedures outlined in Chapter II. The outcomes are then presented in forms of photogeological map of Changwat Khon Kaen and its adjacent areas, as illustrated in Plate No. 1. Broadly speaking, the map contains the following information or legends, namely, (i) Stratigraphy of the study area with respect to photogeological units, boundaries and their relationships ; and (ii) Structural features of the area.

3.2 Stratigraphy of the Area.

The results in aids of rock units, with regard to the lithostratigraphic nomenclature, informal photogeological units have been proposed for the purpose of tentative reference and correlation in this investigation. The study reveals that the area is composed of 10 photogeological units, namely, the Unit A, B, C, D1, D2, E, M1, M2, M3 and Q in ascending sequences. Furthermore, the Q Unit can be subdivided into Q1, Q2, Q3 and Q4 subunits according to their photogeological properties and geological appearances. The thickness

of some measurable photogeological units is determined by using stratigraphical calculation. The results are listed in Table 3.1.

The gross diagnostic characteristics of each photogeological units are vividly examined and correlated to the selected previous works in views of lithological properties, stratigraphic thickness, chronologic sequences, and previous nomenclatures. Some of the results are summarized and illustrated in Tables 3.2, 3.3, 3.4 and 3.5.

Detailed description of each photogeological units within the study area are presented as follows :-

3.2.1 Unit A : Phu Kradung Formation.

This unit is found on the west-side of the study area along the back slopes to the escarpments of Phu Phan Kam around the Nam Phong Reservoir extending to those of Phu Meng in the south. Recognizable features of this unit are the large clusters of low relief hills with scattered and moderate vegetation, medium-grey tone, alternated with nearly flat to rolling topography which is used for paddy cultivation. Coarse-dendritic drainage patterns are frequently observed. The drainage system flows northward to Nam Phong Reservoir. Bedding traces cannot be observed.

From regional observation, bedding of the unit is expected to follow the north-south direction and that

Table 3.1 Thickness of some measurable rock units within the study area (from stratigraphic calculation).

Location (Ban) Rock Unit	Phia Fan	Ba Yao Khok Yai	Don Du	Khao Yai	Hin Hao Sang Kaeo	Phu Meng Hin Kong Pa Manao	Average Thickness (metre)				
E	420.17	498.47	484.83	--	477.31	359.29	448				
D2	229.06	303.31	226.20	241.23	220.07	277.21	250				
D1	169.06	167.87	186.46	138.92	139.25	147.95	158				
C	--	592.42	362.60	140.68	179.53	281.37	311				
B	--	155.30	77.65	129.41	50.03	296.90	142				
Ban Unit	Non Rang : Pa Wai : Som Hong : Pa Mo : Pa San : Nong Lup : Non Muang				Dong Sum : Phak Waen : Dong Ranaeng		Average Thickness of Unit M3 (m.)				
M3	25	39	21	18	31	30	32	43	35	23	30

Table 3.2 Stratigraphic measurements of some Formations of the Khorat Group (after Ward & Bunnag, 1964).

Section no.	1	2	3	4	5	Average Thickness (metre)
Formation						
Khok Kruat	790 *	432	(35)	-	-	570
Phu Phan	82	110	183	135	114 *	125
Sao Khua	487	655	720	512 *	404	556
Phra Vihan	60	115	56	136	87	91
Phu Kradung	1111	803	1001 *	(244)	(321)	972

Remarks :-

* = thickness of the Formation at the type locality.

(....) = incomplected thickness measurements.

Section no.1: along Friendship Highway, from Km. 178.8 to 241.9

Section no.2: along Lopburi-Khorat Highway, from Km. 278.3 to 313.0

Section no.3: Pha Nok Khao-Phu Kradung Area, Changwat Loei.

Section no.4: Nong Bua Lam Phu-Udon Thani Highway, Km. 43.5 to 33.2

Section no.5: Phu Phan Range, Amphoe Kuchinarai, Changwat Kalasin.

Table 3.3 Thickness correlation of the photogeological units and the selected references. Number above the Formation or Unit names indicates thickness range and number in bracket below indicates the average thickness (in metre).

Ward & Bunnag (1964)	Piyasin (1985)	Japakasetr (1985)	This study (1986)
Terrace Gravel	Pleistocene	Top soil	Q Unit
	Sand & Gravel (106)	Sand & Gravel	M3 (30) M2 (?)
0 - 600 Unnamed rocks (-)	-?- Borabu Fm. (586)	58 - 794 Sandstone & Siltstone (-)	-?- M1 Unit (-)
	-?- Maha Sarakham Formation (-)	36-1092 Maha Sarakham Formation (365)	-?- Salt bearing Unit (unexposed) (-)
432 - 709 Khok Kruat Fm. (570)			360 - 498 E Unit (448)
82 - 183 Phu Phan Fm. (125)			220 - 303 D2 Unit (250)
			139 - 187 D1 Unit (158)
404 - 720 Sao Khua Fm. (556)			141 - 592 C Unit (311)
56 - 136 Phra Wihan Fm. (91)			50 - 297 B Unit (142)
803 - 1111 Phu Kradung Fm. (972)			-?- A Unit (?)

Table 3.4 Chronological correlation of the photogeological units as correlated to the selected references.

Sattayarak (1983, 1985)	Age	This study (1986)
Alluvium	Quaternary	Q Unit
Gravel bed	Upper Tertiary to Lower Quaternary	M3 Unit M2 Unit
The Upper Claystone Phu Tok Fm.	Tertiary (?)	M1 Unit
Maha Sarakham Fm.	Late - Upper Cretaceous	Salt bearing Unit (not exposed)
Khok Kruat Fm.	Upper Cretaceous	E Unit
Phu Phan Fm.	Lower Cretaceous	D2 Unit D1 Unit
Sao Khua Fm.	Upper Jurassic	C Unit
Phra Wihan Fm.	Middle Jurassic	B Unit
Phu Kradung Fm.	Lower Jurassic	A Unit



Table 3.5 Summarized stratigraphic subdivisions of the Northeast Region correlated to the study area.*

Eon	Era	MESOZOIC AND CENOZOIC CHRONOSTRATIGRAPHIC SCALE				Brown and others (1953)	La Moreaux and others (1958)	Ward and others (1964)	Iwai and others (1966)	Gardner and others (1967)	Maranata (1982)	Dept. Min. Res. (1984)	Sattayarak (1983, 1985)	Pisuth-Arnon and others (1986)	The present study (1986)																			
		Period	Epoch	Age	Age in Ma.																													
PHANEROZOIC	MESOZOIC	Triassic	Lower T	Induan	235	THE KHORAT SERIES	THE KHORAT SERIES	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP	MS. Evaporites	A Unit																			
				Olenekian	221											PK. M.	NP. Fm.	HHL. Fm.	PK. Fm.	PK. Fm.	PK. Fm.	PK. Fm.	PK. Fm.	PK. Fm.	PK. Fm.	PK. Fm.								
				Anisian	207																						PW. M.	PK. Fm.	PK. Fm.	PK. Fm.	PK. Fm.	PK. Fm.	PK. Fm.	PK. Fm.
			Ladinian	192	Upper T																													
			Carmanian	174												Middle T	PW. Fm.	PW. Fm.	PW. Fm.	PW. Fm.	PW. Fm.	PW. Fm.	PW. Fm.	PW. Fm.	PW. Fm.									
			Norian	149	Lower T																					SK. Fm.	SK. Fm.	SK. Fm.	SK. Fm.	SK. Fm.	SK. Fm.	SK. Fm.	SK. Fm.	SK. Fm.
		Rhaetian	135	Upper T		PP. Fm.	PP. Fm.	PP. Fm.	PP. Fm.	PP. Fm.	PP. Fm.	PP. Fm.	PP. Fm.	PP. Fm.	PP. Fm.	PP. Fm.																		
		Jurassic															Lower K	Upper K	Cretaceous	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP							
		Cretaceous				Albion	Cenomanian	Upper K	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP	KHORAT GROUP																		
		Tertiary															Paleocene	Eocene	Oligocene	Miocene	Pliocene	Pleistocene	Holocene	Terrace gravel	Terrace gravel	Terrace gravel	Terrace gravel	Terrace gravel						
		CENOZOIC				Paleogene	Neogene	Quaternary	CENOZOIC	CENOZOIC	CENOZOIC	CENOZOIC	CENOZOIC	CENOZOIC	CENOZOIC	CENOZOIC													CENOZOIC					

* Note : The abbreviations used in this table are as following :- Fm=Formation, M=Member, E=Cretaceous, J =Jurassic, T =Triassic, IS=Loe Sak, HHL=Huai Hin Lat, NP=Nam Phong, PE=Phu Eradung, PW=Phu Wihaen, SI=Sao Khua, PP=Phu Phan, IX=Ihok Krust, MS=Maha Sarakham, PT=Phu Tok, BNY=Ban Na Yo.

constituting the innermost part of the southerly plunging Phu Meng Anticline. General appearance of the unit is flat to gentle undulating terrains, covered with residual and/or transported surficial deposits. Outcrop exposures cannot be detected except for that of small fragments of reddish brown, friable, micaceous siltstone obtained from shallow dug-wells in some places. Land use in the flat portions is for paddy field. In the hilly and footslope areas, pea gravel laterites are associated on open forest.

According to the selected previous works and field identification, this unit is equivalent to Phu Kradung Formation of Lower Jurassic age.

3.2.2 Unit B : Pra Wihan Formation.

Elongate strip of ridge - forming, gently to moderately dipping eastward and overlying Unit A (Figure A-1-1). Bedding with dip slope is clearly observed. Photocharacteristics of the unit are medium to dark grey tone, coarse texture with moderate vegetation, coarse-parallel and trellis drainage pattern. The unit is very high resistant rocks alternated with thinly non-resistant beds. Highly dissected features are shown normally perpendicular or oblique to the regional trend.

Field observation reveals that this ridge-forming terrain, especially at Phu Meng, has the highest elevation (642 m. AMS). The topography is elongated hilly to mountainous with open to dense forest. Rock exposures

can be found throughout the area. The unit consists mainly of resistant, thick to massive layers of light colour, coarse-grained sandstone intercalated with pebbly sandstone, conglomerate and siltstone. Sandstone which exposed at the uppermost portion of the exposures usually shows very irregular top surface with polygonal, shallow incised erosional cracks. These polygonal cracks are well developed on mound-like shape with relief approximately 2-5 centimeters height. Pot holes of various diameters are also encountered. Colluvial deposits of milky quartz gravels derived from this unit are common along the dipping footslope portion. Cross bedding and associated internal structures are well observed. Most of them indicate paleocurrent in the south or southwest direction. The strike of sandstone bed more or less north and dips about 15 - 20 eastwards. From the small scale image, southerly plunging anticlinal structure is clearly depicted to this unit, particularly in the vicinity of Phu Meng area.

From the outcrop pattern and distribution of this unit, the thickness is calculated to be 142 m. In comparison to selected previous works, this unit is equivalent to Phra Wihan Formation of Middle Jurassic age.

3.2.3 Unit C : Sao Khua Formation.

The orientation of this unit is conformable with those previously described. It appears in aerial

photograph as gentle broad valley of low relief located in between relatively more resistant units. Aerial photograph characteristics of the unit are medium to light gray tone, granular texture, rolling to undulating terrains with occasional flat lying topography, sparse vegetation and low to moderate resistance (Figures A-1-1 and A-1-3). Trellis drainages patterns are more well-developed than the previous units. Bedding traces can be observed using erosional patterns of drainage pattern along resistant and non-resistant beds within the unit. Beddings are gentle dipping to east and gradually to southeast in the southern and northern part of the area.

Ground observations indicate that, this unit forms the area of flat to undulating topography which is mainly used for paddy cultivation and upland crops, respectively. Outcrop exposures are scarce, exception to the north of Phu Wat footslope (about 5 km., SE of Phu Meng). The rock found in this unit is pale to reddish-brown, fine to very fine-grained, well-cemented to friable, micaceous sandstone. From outcrop pattern, the calculated thickness is 311 meters.

This photogeological unit is equivalent to Sao Khua Formation of Upper Jurassic age.

3.2.4 Unit D1 : Phu Phan Formation.

This unit appears as dense vegetation, hilly terrain overlying the Unit C. It shows dark to dark gray

tone and coarse texture on the aerial photographs. Less drainage density is developed along cross joint pattern. Beddings are obscured but they can be traced. They are easterly gentle dipping to sub-horizontal. The unit is high resistant and permeable.

Field evidences indicate that the area is nearly flat top hill to undulating terrain normally covered with forest and cultivated land producing cassava, sugar cane, and jute. Rock exposures are along the streams and dip slope in a number of localities for example, Ban Hin Hao (Figures A-1-2 and A-1-3), Phu Wat, Ban Hin Khao, etc. The unit is characterized by thick, resistant, light color of pebbly sandstone, coarse-grained sandstone and conglomerate. Pebbles in the conglomerate are rounded to subangular quartz, chert and fragments of igneous and metamorphic rocks. Bedding and cross-bedding are common. The attitude of bedding is conformable with the underlying Unit C. Residual and colluvial deposits of sands and gravels are encountered along the footslope portion and/or in between the non-resistant beds which are completely degraded.

The calculated thickness of this unit is averagely 158 meters. Comparing the information acquired regarding this unit to that of previous works, it is parallel to Phu Phan Formation of Lower Cretaceous age.

3.2.5 Unit D2 : Phu Phan Formation.

The photo characteristics of this unit are similar to the Unit D1. This unit, generally, occurs at lower elevation and much more wider spreaded. Erosional features are also more intensive. In relation to the Unit D1, it forms an extensive slope and less resistant. Lighter gray tone is depicted

Field evidence shows that most of the area of this unit along footslope and broad valley are used for paddy field while at higher elevation is used for upland crops and abandoned land of open forest. Rock exposures are rarely found except where the rocks occupied at some deeply roadcut or some drainage ways. Lithologically, the rock consists of pale orange to yellowish gray, medium to coarse-grained sandstone with micaceous and small fragments of rock detritus. Bedding are not clearly observed because of the poor exposure. Thickness of the unit derived from calculation is about 250 meters.

This unit is mapped to Khok Kruat Formation (Chonglakmani, et al., 1979). In this present study, from the aerial distribution and its gross properties, this unit is more likely to be the upper part of Phu Phan Formation. Therefore, Unit D2 is proposed and correlated to Phu Phan Formation of Lower Cretaceous age.

3.2.6 Unit E : Khok Kruat Formation.

This unit is confined along the flat to undulating topography as indicated in Figures A-1-1, A-3-1, and A-6-1. Anticlinal or dome-like feature is observed at Ban Nong Pan area (Figure A-2-1). The unit is characterized by two different types of landform. One is gentle to slightly undulated landform and photographically light gray to medium gray. The other occurs in higher elevation. It is gentle and show medium gray to dark grey and coarse texture. Vegetation and landuse patterns are also different between the two landforms. Paddy fields are common for the first landform while the other is for upland crops and open or dense forest. The higher relief areas are also common for human settlement such as village locations. This unit, as evident from highly abundant of drainage, is the most obvious terrains of non-resistant underlain rocks with respect to the surrounding trrrains.

Field observations of the unit show that it is spreaded from the northeast of the area(Figure A-13-1) immediately to the north of Khon Kaen town (Figure A-6-1) and along the inner west boundary through the south of the study area. Outcrop exposures can be observed in many places from the paddy area up to the higher elevation through the above mentioned areas(Figures A-6-1, A-3-1 and A-2-1). The rocks found are of two types, namely, pale red to reddish brown, fine-to medium-grained, micaceous and the more resistant, purplish red to reddish brown, well-

cemented, calcareous, pebbly sandstone and siltstone. Some beds contain pebbles of purplish red, indurated siltstone or mudstone with diameter of 3-5 mm. Rock strata is obvious and well developed. The orientation of the unit is gentle and conformable to that of the previous units.

Some parts of this unit was mapped previously as the Maha Sarakham Formation (Chonglakmani, et al, 1979; DMR.,1984). The present study, however, consider that the lithological properties and diagnostic characteristics of this unit as findings above, can be correlated to the criteria given by Ward and Bunnag (1964), and Sattayarak (1983). For this reason, Unit E is considered as the Khok Kruat Formation.

3.2.7 Unit M1 : The Upper Claystone.

This unit is widely exposed in the south to central parts of the area in the vicinity of Amphoe Kosum Phisai, Amphoe Ban Phai and Amphoe Borabu. The photo characteristics of Unit M1 show coarse texture, dark to dark gray tone, except for erosional drainage patterns showing light gray tone and matted texture. Dense vegetations are observed on rolling to undulating landforms. Cultivations are also depicted along the erosional drainage ways. Permanent streams are not abundant except for narrow shallow valley with intermittent water bodies. These drainage ways are interpreted to form along the joint patterns as can be observed clearly at Phalan Hin Koeng (Figure A-7-1).

Less abundant drainage density indicates that the M1 Unit is more or less permeable and topographic expressions such as drainages, relief, and alternating white and gray tone are caused by different characteristics of the materials and position of the bedrock underlain.

Observation on Landsat imagery shows that the area is a zone of broad gentle fold. The fold axes are seemingly lying in north-south direction. It has to be noted that, at this stage of study and due to the scarcity of rock exposures, detailed field check for the folding features cannot be much done. The interpretation of this structure is derived from the comparison of such the same topographic and geologic patterns to the known area. Besides, numerous of photo lineaments in NW-SE and NE-SW directions are much developed and can be traced. Those sets of lineaments are interpreted to be joint sets of the unit according to their image appearances and field evidences in some places mentioned above.

Field mapping of this unit shows that the area is mainly covered by thick to very thick sandy soil, light pink to pale red in colour, covering a rolling topography of the area. Outcrops exposed only along the deeply eroded drainages such as at Huai Ma Tai, Ban Sawang located approximately half distance between Khosum Phisai and Maha Sarakham province. The most obvious exposures are at Wat Phalan Hin Koeng as illustrated in Figure A-7-2.

The rock are also exposed at the southern bank of the Chi River in the vicinity of Khosum Phisai. Lithologically these rock types are low to moderate resistant, brick red to pale purplish and pale orange color, massive to thin-bedded, friable, well-sorted, fine to medium-grained sandstone with some of micaceous interbedded with siltstone and mudstone. Gypsum crystals and/or nodules are frequently found within the rock. Small scale cross-bedding and cross-lamination are also recognized. Their attitude are nearly horizontal with varying dip direction from place to place. Numerous steep dipping joints of NW-SE trending are generally displayed. Moreover, the NW-SE trending steep dipping joints are also recognized within this rock region.

Lithologically, the Unit M1 is agree with the description of the Upper Claystone given by Sattayarak (1983). Consequently, it is also proposed as Borabu Formation of Tertiary age by Piyasin (1985).

3.2.8 Unit M2 : -

The vicinity of Amphoe Ban Fang and Amphoe Phra Yun which are located on the central portion of the area and the vicinity of Amphoe Chiang Yun on the east side of the area are covered with Unit M2. The aerial photograph appearance is dark to dark gray tone and coarse texture. Topographic expression is normally higher relief than the surroundings. The terrain is splitted up

into small low hills arranged in specific trends. For example, at the vicinity of Amphoe Ban Fang the trends are NW-SE and E-W directions whereas at that of Amphoe Phra Yun is in the NE-SW direction. The distribution and trends of this unit are definite. Plenty of ponds are associated with the edge of the unit (Figures A-4-1 and A-11-1) producing the photo characteristic of light gray tone and fine texture throughout the rim of the unit. Structural conditions of the area cannot be clearly observed from the aerial photographs. However, regional structural features such as folding can be delineated from Landsat images. For example, the N-S trend folding, can be deciphered at the vicinity of Amphoe Chiang Yun as distinguished from the area of Ban Fang and Phra Yun for folding in different directions.

Many field evidence indicate that the area is broad nearly flat to rolling terrain. Surficial deposits of silty sand, sandy soil and lateritic soil spread throughout the area. The pea gravels and gravelly laterite are widely spreaded in Chiang Yun area. The hardpan of approximately 40 cm. thick of low level laterite is also associated. Generally, outcrops are found in the area where the rate of erosion of the Unit M2 is considerably high. This results a gentle terrain covering with pale red, reddish, loose sandy soil. Its contents of clayey and organic materials is notably low. The white patch features of saline soil can be found around the

footslope of low relief portions.

No formal nomenclature of this unit has been proposed in the previous works. At this study it is proposed to be the M2 Unit of Tertiary (?). The proposed age is Upper Tertiary to Lower Quaternary which derived from the correlation as illustrated in Table 3.4.

3.2.9 Unit M3 : Gravel Petrified Wood Bed.

A long broken strip topographic feature following the regional trend of the underlying rocks of C, D1, D2 and E Unit is the Unit M3. Its distribution begins from the southernmost of the area at Ban Nong Pan (Figure A-2-1) through Ban Fang to the north then curving southeast to the Khon Kaen air field and Khon Kaen University campus (Figure A-6-1). The strip turns north to Amphoe Nam Phong and traverses to the east, passing through the north of Amphoe Chiang Yun (Figure A-13-1). The trend of this unit is concordant to regional structure of the area.

Photo characteristics show medium to light gray tone with coarse texture and moderate vegetation. Generally, the terrain is of higher relief than the surrounding units. Particularly, this unit forms elongated hills. The present cultivation land, however, do not appear on the photos. The scarcity of drainages definitely indicate the underlying rocks of the area are permeable. This unit is characterized by relatively

higher elevation, continuous distribution pattern and less drainage density.

In addition, field evidences indicate that, this unit is characterized by its unconsolidated deposits of red-yellow soil, gravels and laterites. The details of each component are described in an descending sequence as follows:

The layer of red-yellow soils, consists mainly of loose sandy soil to sandy loam. The layer is prominent in colour of reddish orange and various hues of brown and without any distinctive depositional features. The thickness of the layer is various, ranging from 1 - 15 m.

There are two types of laterite layers in this unit. The most common is massive bedded laterite and the other is gravelly laterite. These laterite layers are approximately 0.2 to 1.5 metre thick.

The next descending layers are loosely packed of siliceous gravels. In some places, they are alternated by unconsolidated sand. The average thickness is 2-8 metres. It should be notice that in these siliceous gravel layers, various size of petrified wood are common. Perhaps the existence of these petrified wood might be an important index fossil for correlation and characterization of this unit.

Stratigraphically, this unit is overlying on the

partially degraded surface of Unit E. This is evident in many localities, e.g. Ban Nong Pan area (Figure A-2-1), Ban Non Rang area (Figure A-3-1), Ban Non Muang area (Figure A-6-1). Besides, they also occur further away from the study area, that is, in the vicinity of Amphoe Mancha Khiri, Nam Phong and Kra Naun. The average thickness of Unit M3 is 30 metres (Table 3.1). According to Sattayarak (1985), the unit was named the Gravel Bed and designated as Late Tertiary to Early Quaternary of age. For this study, the Gravel Petrified Wood Bed is proposed for the informal name of this unit due to its diagnostic characters as described above.

3.2.10 Unit Q.

Alluvial deposits of the Quaternary can be observed throughout the study area. The main deposits are along various size of streams. The unit can be subdivided into 4 subunits as follows:-

3.2.10.1 Subunit Q1 : This subunit occurs throughout the area except in the flood plain portion. In the aerial photographs, this subunit characteristically shows a certain shade of light gray tone with matted and fine texture. It is characteristically gentle all over the area. Within the subunit, no sharp relief difference can be detected. Paddy cultivation are observed throughout the subunit (Figures A-1-3, A-3-3 and A-4-2-B).

In the field, the light gray tone is unconsolidated washed sand, while the darker gray is residual deposits of clayey sand composition. Ferruginous lateritic materials are also found either as concretions or cemented sheets embodied in the later one. In relation to the M2 Unit, this subunit is its outer part which shows white patches of saline soils. Topographically, the Q1 subunit is gently dipping to nearly flat-lying terrain.

3.2.10.2 Subunit Q2 : This subunit occurs at higher portion of the Quaternary deposits. It spreads along main rivers. Photographic tones are medium to dark gray with granular texture. Depression features such as ponds and low-lying paddy fields are abundant (Figures A-10-1 and A-12-1). The areas are flat to slightly undulating. Soil of the Q2 subunit is mainly yellowish brown clayey soil.

The landform of this unit is slightly undulating to nearly flat-lying terrain. The landuse is confined to mainly upland crops mixed with deciduous forest. All information obtained from the borrow pits, dug well and from groundwater well logs indicate that this subunit varies in thickness ranging from 2-25 metres and usually consists of thin layer of gravel in the lower part.

3.2.10.3 Subunit Q3 : This subunit is separated from subunit Q4 based on position of occurrence, relief, relationship to other units and its morphology.

The subunit Q3 is located within the flood plains of Lam Nam Phong and Lam Chi. Flat swampy areas are common. The image characteristics are dark to dark gray tone and fine texture.

Field observation indicates that most of the area is abandoned land of swamps and marshes (Plate No.1). Salt crusts or patches are not found. Natural large ponds and lakes are normally associated. Soil material found in the field is frequently gray to dark gray clayey soil.

3.2.10.4 Subunit Q4 : This subunit widely spreads along the broad low lying flood plains of Lam Nam Phong and Lam Chi. Natural levees, oxbow lakes, back swamps, point bars and meander scars are associated landforms within this subunit (Figures A-8-1 and A-12-1). This subunit shows various types of photo characteristics. Generally, light to light gray tone and fine texture are the gross characteristics of this subunit. Topographic expression is flat. Anastomotic drainage pattern is clearly observed. Meander scars are also abundant within the area (Figure A-12-1). Paddy cultivation is wide spread in this subunit. Figure A-8-2(B) illustrates the subunit Q4 landforms which include flood plain, natural levee of Lam Nam Phong, and the landuse features. Flat-lying terrain is shown in Figure A-12-2(B). Soil are composed mainly of very fine-grained of river deposits, e.g., silty and clayey soils of pale yellow to pale gray in color.

3.3 Structural Geology of the Area.

According to the image interpretation of aerial photographs and Landsat imageries, together with some field investigations, the geological structures of the area can be concluded as follow:-

The exposed rock units that can be recognized through the outcrop patterns show horizontal to subhorizontal conformable beds with approximately inclination of 5-20 degree. The stratigraphic succession of these units can be traced from aerial photographs in an ascending order as units A, B, C, D1, D2, E and M1. The relation between M1, and E is not quite clear from the image, however many literatures review that M1 or the Upper Claystone (Sattayarak,1983) is disconformably lying over unexposed salt-bearing unit which also disconformed over E. Therefore, M1 must be disconformed over E also. Besides these rock units, unconsolidated sediments of M2, M3 and Quaternary surficial deposits of Q Unit with Q1, Q2, Q3 and Q4 Sub-units are found widely cover the area (Plate no.1 and Figure 3.1). According to the well log data of the investigation within the study area, they suggest that relation between M2 and M3 should be transitional to gradational deposits with lateral gradation contact. Though strata of M2, M3 are still not clear and in controversial, photo interpretation shows more or less, M2 and M3 are horizontal to subhorizontal conformably overlying the rock units. Field investigation

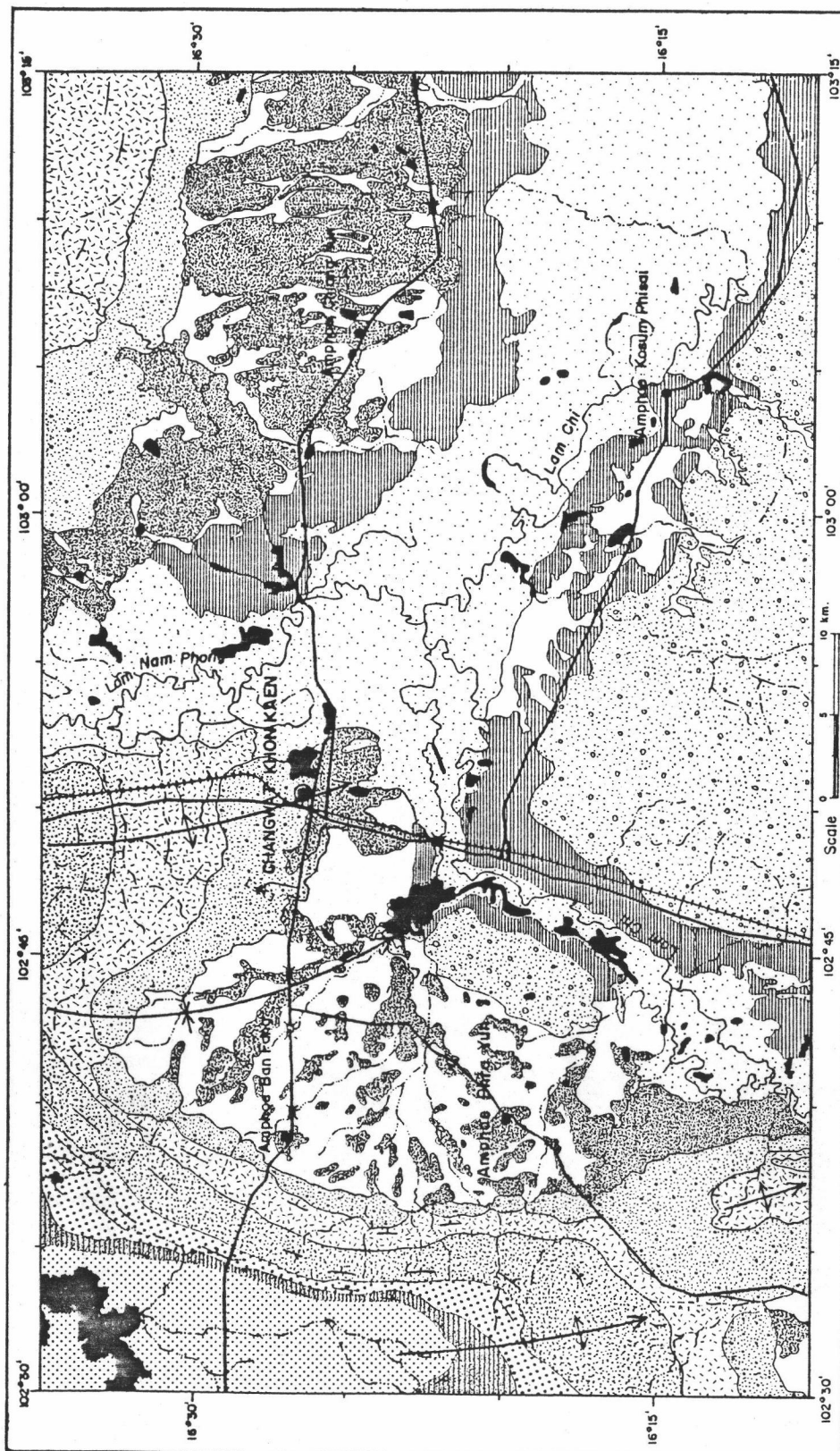
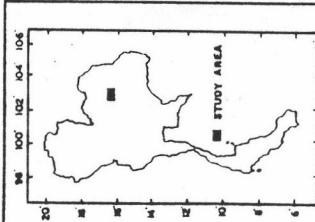
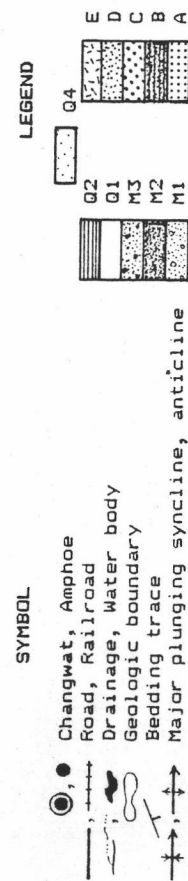


PHOTO-INTERPRETATION FOR
GEOLOGICAL MAPPING OF CHANGWAT
KHON KAEN AND ADJACENT AREAS.

Somyot Hokjaroen

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

Figure 3.1 Geologic map of the study area interpreted from
Landsat imagery (MSS, Band 7).



also indicates that M3 certainly disconformably overlies E unit.

A series of non-cylindrical, en-echelon open fold are detected from Landsat imagery and confirmed by field investigations for some area only due to the limitation exposure. The geologic cross sections of line A-A', B-B' and C-C' (Plate 1) also reveal these folds as shallow anticlines and synclines. Moreover, these folds are believed to be a part of a broad syncline with south plunging. These fold systems are analyzed in a form of rose diagram of fold axes (Figure 3.3--B). These axes trending are appropriately determined to be the major axis of the folded rock region all over the study area with an attitude about north-south direction. In addition to the study above, Figure 3.3-A and Figure 3.4 are carefully demonstrated.

Furthermore, lineation from photolineament are also analyzed statistically in the same manner as depicted in Figures 3.2-C, 3.2-D and 3.2-E. These lineaments can be classified into cross-, longitudinal- and diagonal-fractures as related to the fold axes. Cross- and longitudinal-fractures indicate extension features whereas the diagonal- ones indicate shear features (Billing, 1972 and Price, 1981). These results incorporating with fold axes analysis, the author suggests the direction of major principal stress that acted in the area probably in the east-west direction.

Piyasin (1985) stated that Huai Hin Lat, Nam Phong and Phu Kradung Formation of the Khorat Group were subjected to two tectonic events, namely, the Indosinian orogeny and Himalayan epeirogeny. While Phra Wihan, Sao Khua, Phu Phan and Khok Kruat Formation are subjected to only Himalayan epeirogeny. Therefore, the rocks in unit A, as correlated to Phu Kradung Formation, ought to be effected from both Indosinian orogeny and Himalayan epeirogeny while the rest effected from the later one.

Figure 3.2 shows that most tension fractures are common in units A,B,C,D,E,M2 and M3, while shear fractures quite pronouce in M1. Though, Unit A, subjected to two tectonic events, the lineation does not show intense fractures. On the contrary, Unit M1 shows a large number of intense fractures. This contact is probably due to the difference in physical and mechanical properties of rock units. Moreover, the deformation of underlying salt-bearing unit may cause more fractures in Unit M1.

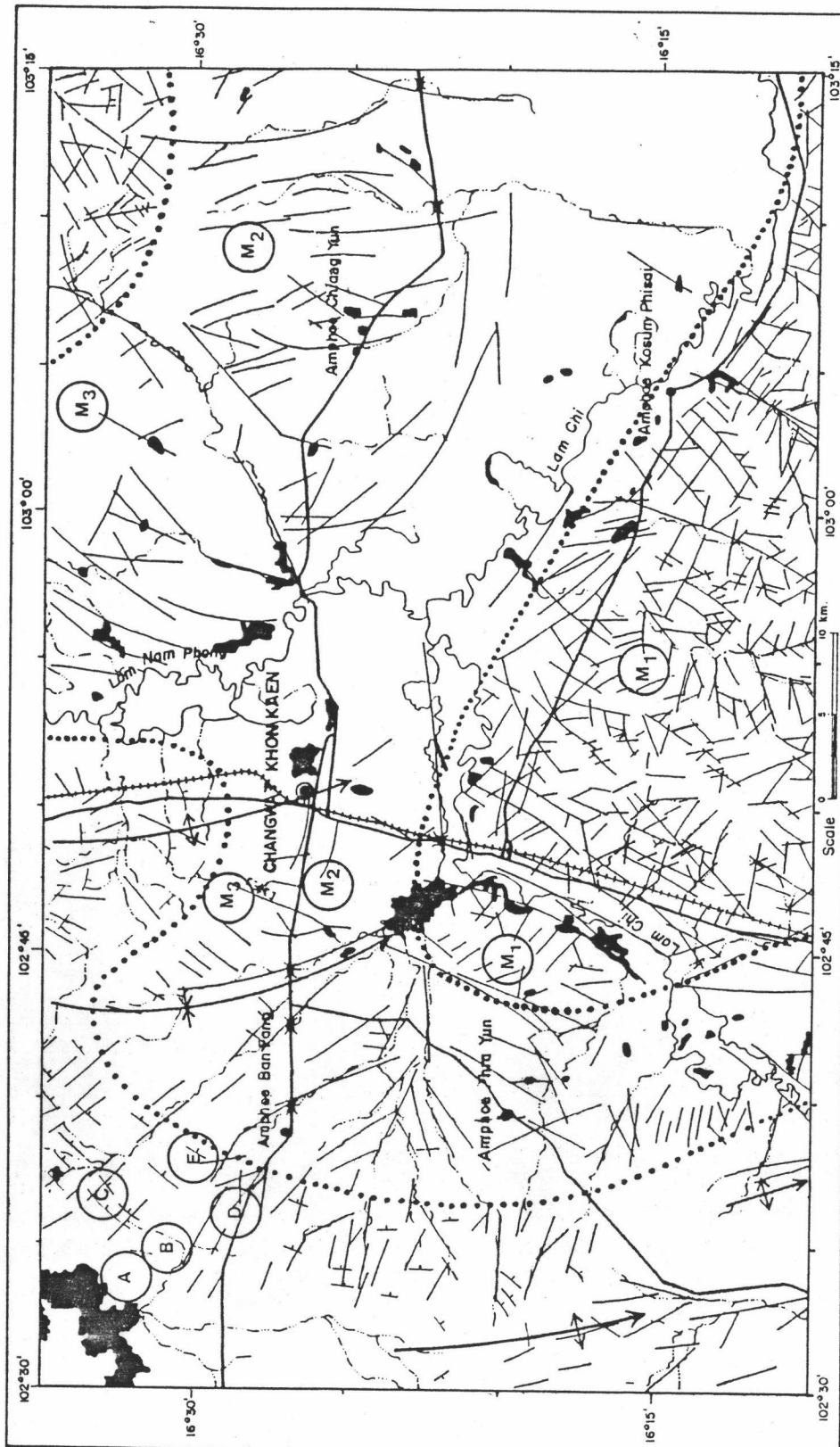


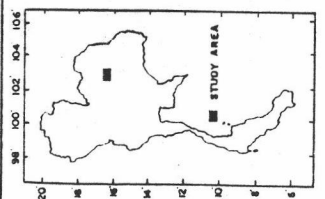
Figure 3.2 Map showing photolineament zones and some characteristic features. The structures are directly interpreted from Landsat-3 imageries of 1:250,000 original scale.

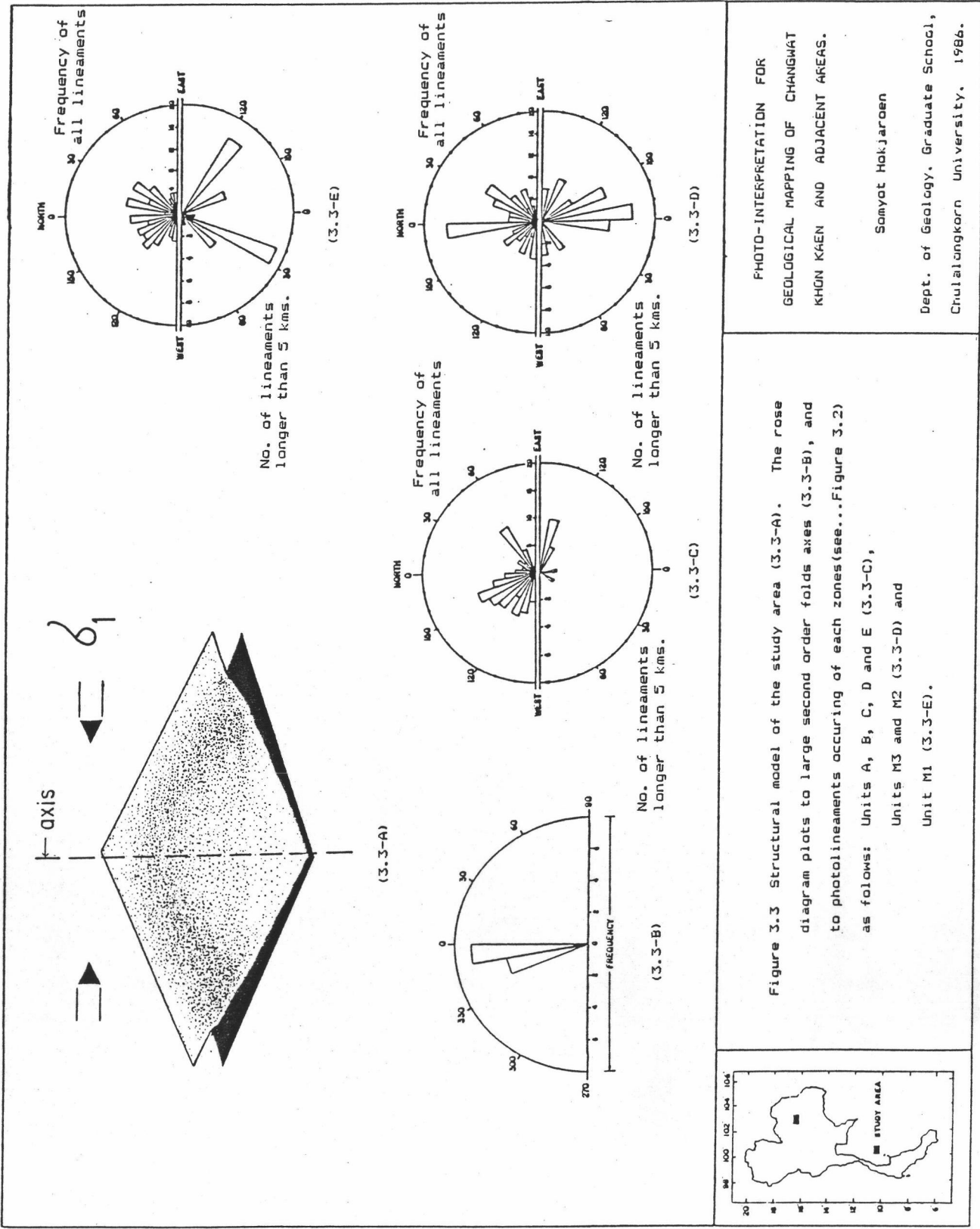
GEOLOGIC LEGEND

- Fractures (fractures)
- Bedding traces with low angle dip (5 -20)
- Large-second order folds of anticline and syncline
- Rock units
- Photolineament boundary zones

PHOTO-INTERPRETATION FOR
GEOLOGICAL MAPPING OF CHANGWAT
KHON KAEN AND ADJACENT AREAS.

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





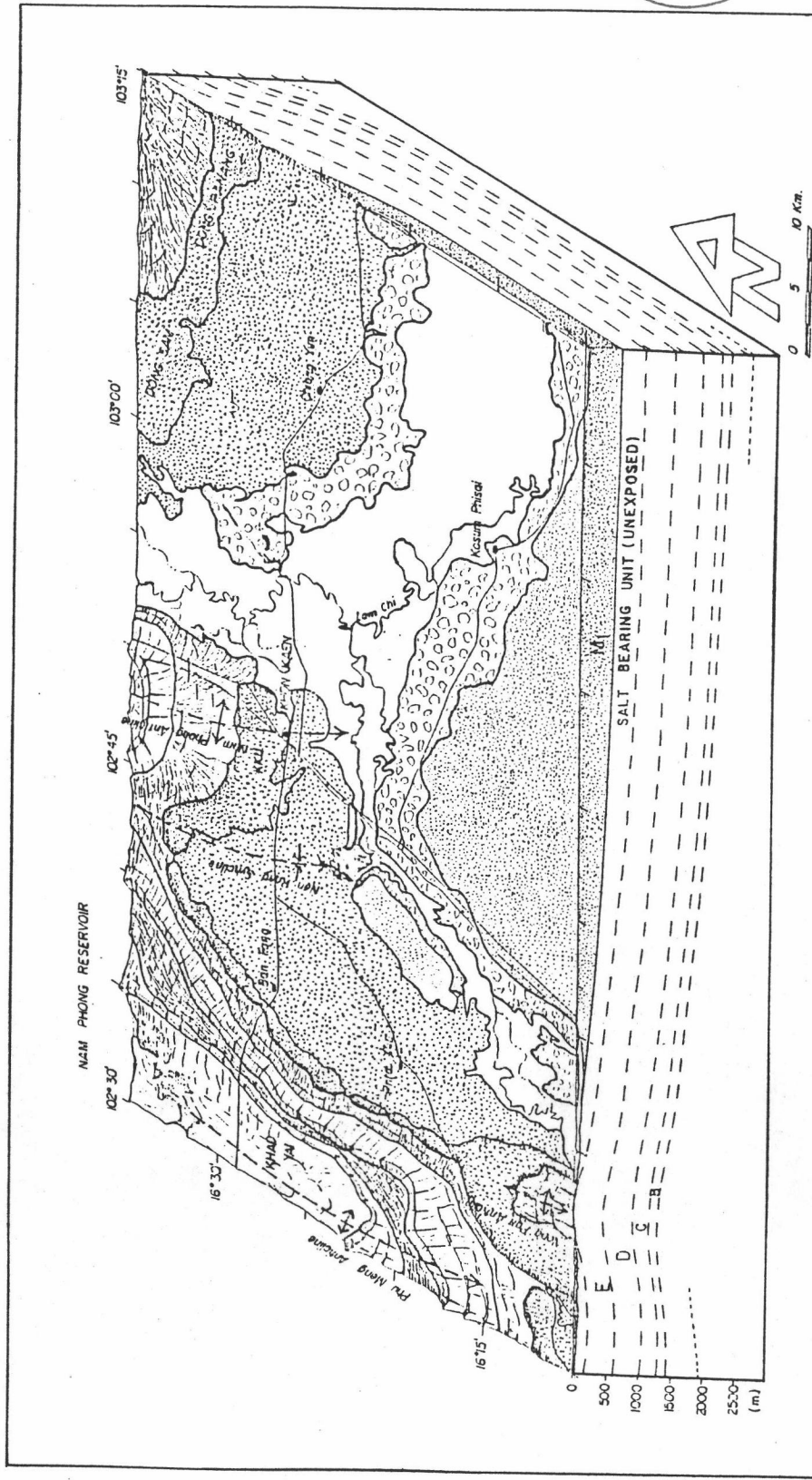


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Figure 3.4. Schematic block diagram of the study area.
Constructed from the geological map in Figure 3.1.
The representative thickness of each geological
unit is obtained from Table 3.1.

