CHAPTER II

METHODOLOGY

2.1 General.

" Remote Sensing " can be broadly defined as the information collection of an object employing electromagnetic energy including light, heat and radio-waves as the means of detecting and measuring target characteristics. The definition of remote sensing excludes electrical, magnetic and gravity surveys that measure force fields, rather than electromagnetic radiation. Aircraft and satellite are common platforms from which remote sensing observation are made.

Three main processes, namely, data acquisition, data analysis and data application, are involved in remote sensing system. Among these processes, data analysis is the most important one for obtaining required information leading to general interpretation in a study programme. Data acquisition procedure concerns pictorial and numerical data. In this study, pictorial data, particularly black and white aerial photographs and Landsat imageries are used as part of geological mapping through visual interpretation techniques. Numerical data which requires automatic data processing facilities are omitted in this study programme due to the lacking of

sophisticated equipments and research fund. Nevertheless, the numerical data for any areas investigated, can be produced into imageries from their original data. The productions are not only black and white imageries in various scale but also diapositive false color composites (FCC) which can be studied directly by visual interpretation.

Information extracted from image interpretation are gathered and utilized to form fundamental key data for the mapping. Image interpretation by means of visual interpretation techniques are employed in this investigation because it is hoped that the techniques would resolve the problems of physiographic limitation, the lacking of sophisticated survey equipments and research fund.

2.2 Investigation Procedure.

The investigation procedures employed in the study are summarized in Figure 2.1. Detailed investigation procedures can be broken down into following stages:-

2.2.1 Planning and Preparation.

Planning and preparation for investigation are the prime important stage in any research, the investigation and work plan for this geological mapping scheme is planned and prepared based on stated objectives, appropriate approaches, and data sources as in the

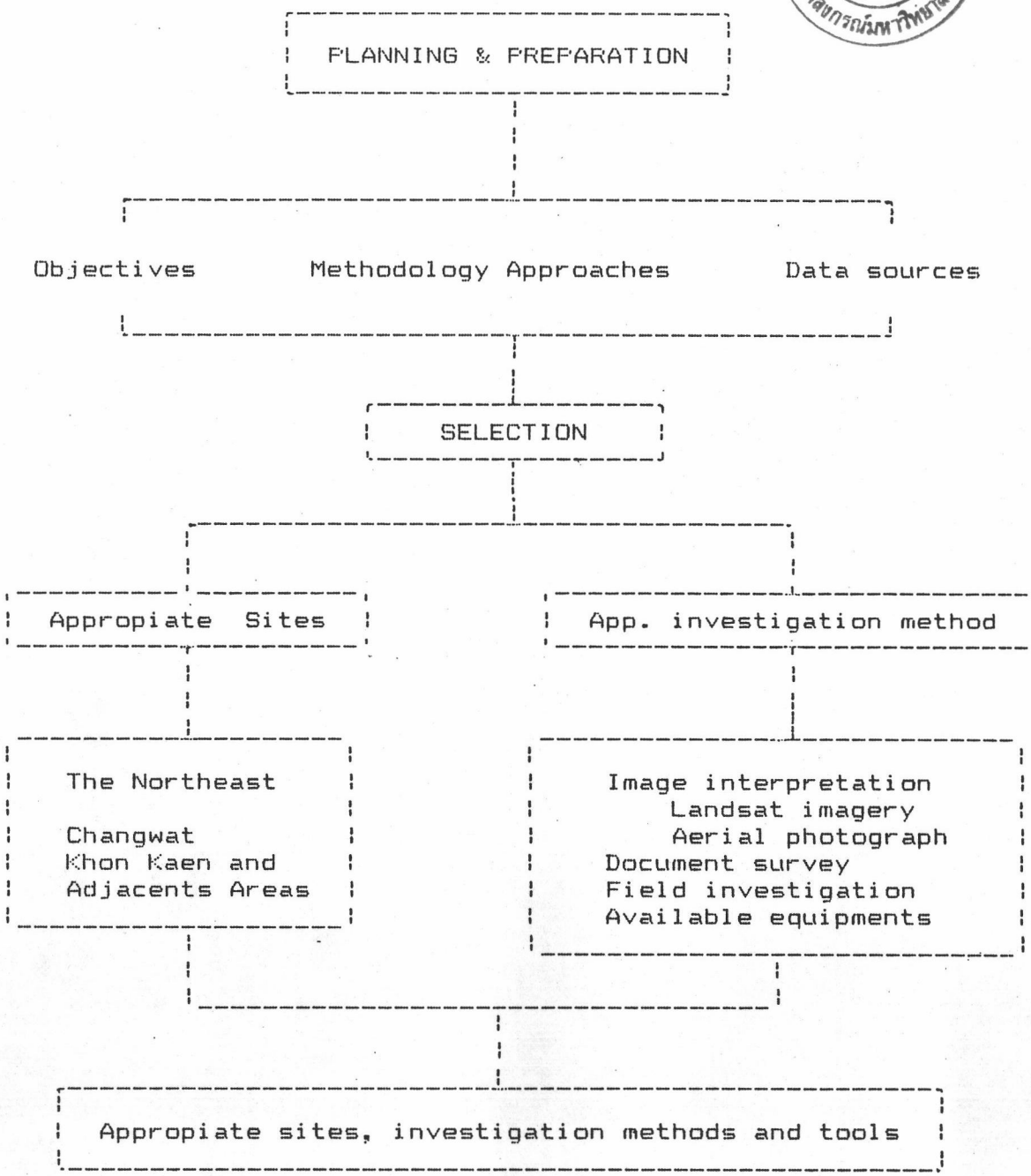
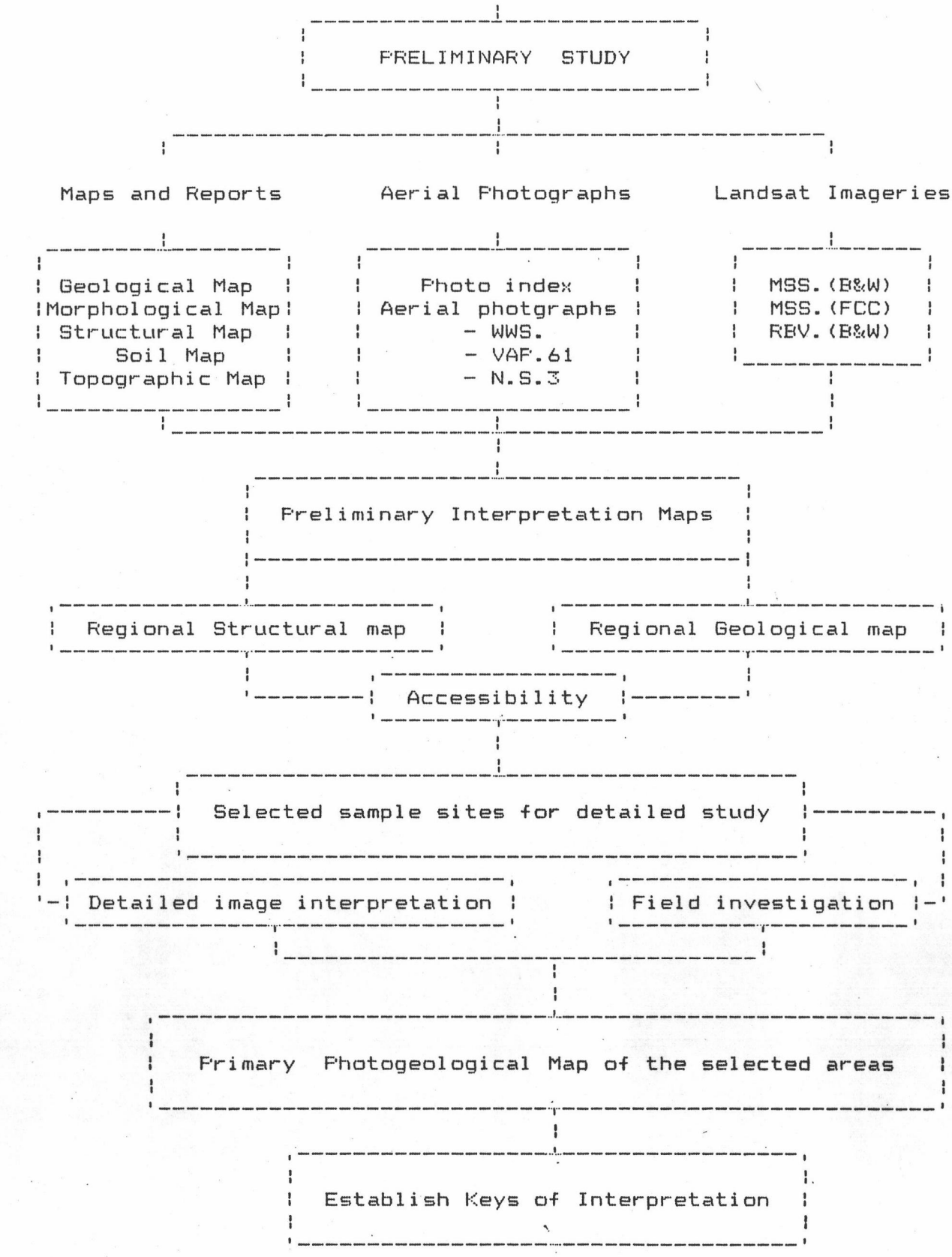


Figure 2.1 The summarized flow charts illustrating the study methodology for the study programme.



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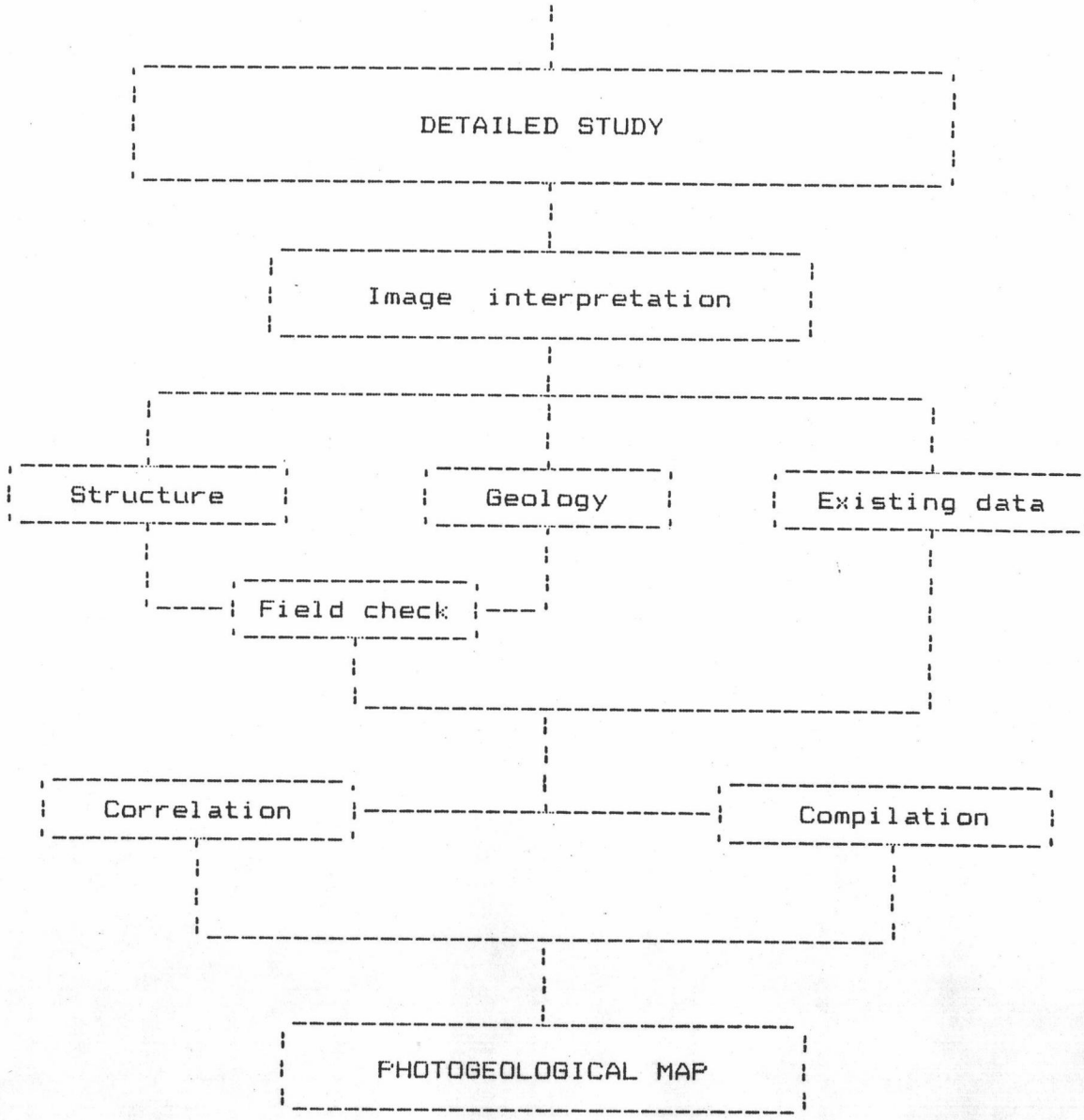


Figure 2.1 cont.

following :-

2.2.1.1 Selection of Appropriate Sites.

Due to the fact that the Northeast region is a large area covering about one third of the whole country, geological mapping of the region is difficult because of surficial deposits conceal most of rock exposures. Application of remote sensing techniques, therefore, seem to be promising solution. Khon Kaen and its vicinity are considered appropriate and selected for this study due to the following considerations :

a. They show simple geological sequences and possess simple structural conditions that can be representative of Khorat plateau both stratigraphically and physiographically.

b. Considering time frame and available research fund, Khon Kaen is logistically most suitable for the study area for the investigator is living there and familiar to the region. Field mapping and transportation cost could be largely alleviated

c. Khon Kaen is one of the principal towns of the Northeast where various current research and development projects are being undertaken both by private organizations and government agencies. Therefore, mapping of the area would provide base-line information for those research and development activities.

According to geological conditions, the approximate total study area of 3,680 square kilometers are considered appropriate.

2.2.1.2 Selection of appropriate investigation method and tools. Investigation methods are restricted to available facilities. In this study, image interpretation through mirror stereoscope is utilized incorporating with selected Landsat imageries and aerial photographs together with photo index and selected 1:50,000 scale topographic maps. Besides, the investigation on existing geological information and through the study area selected are essential for correlation and compilation of the results.

Aerial photographs available for the study area are obtained from the Royal Thai Survey Department. These include three series of aerial photograph projects, namely, WWS.(1954), VAP. 61 (1967) and N.S.3 (1975). The advantages of these aerial photographs produced by each project are previously tabulated in Table 1.3. Based on the advantages summarized, the WWS aerial photograph series are selected to use in this study. Besides, the photo index of the aerial photograph selected are also eaxmined as shown in Figure B-1.

Landsat imageries form essential part of this investigation. Landsat information is available in two forms, namely, pictorial and numerical data. Data

analysis can be performed either by manual interpretation for pictorial data or automatic data processing for numerical one.

Landsat numerical data can, however, be produced into pictorial data which is ready for direct interpretation. The advantages of Landsat imageries are those they are multidates and multibands. Interpretation for regional features is considered appropriate. However, Supajanya (1981) indicated that detailed study on moisture contents of the land surface can readily be achieved by using appropriate selected imageries. Multidate and multiband Landsat imageries are compared and found that those taken in 1979 give the best image quality and therefore, selected for this study. Figures B-2 and B-3 are illustrated for the MSS. and RBV. imageries selected.

Relief, drainage patterns, and transportation route networks can be readily obtained from topographic maps. The topographic maps of 1:50,000 scale are designated as working base maps to be congruent with selected aerialphotograph scale. The topographic maps of 1:250,000 scale incorporating with photo index and imageries are not only employed to delineate primary regional geological features and soil distributions but also applied to derive regional folding and lineaments. The information obtained from this investigation are compiled and presented in a map of 1:100,000 scale. For illustrations in the report, most of the maps are reduced

from 1:250,000 to approximatelty sacle of 1:390,625 to fit the report format.

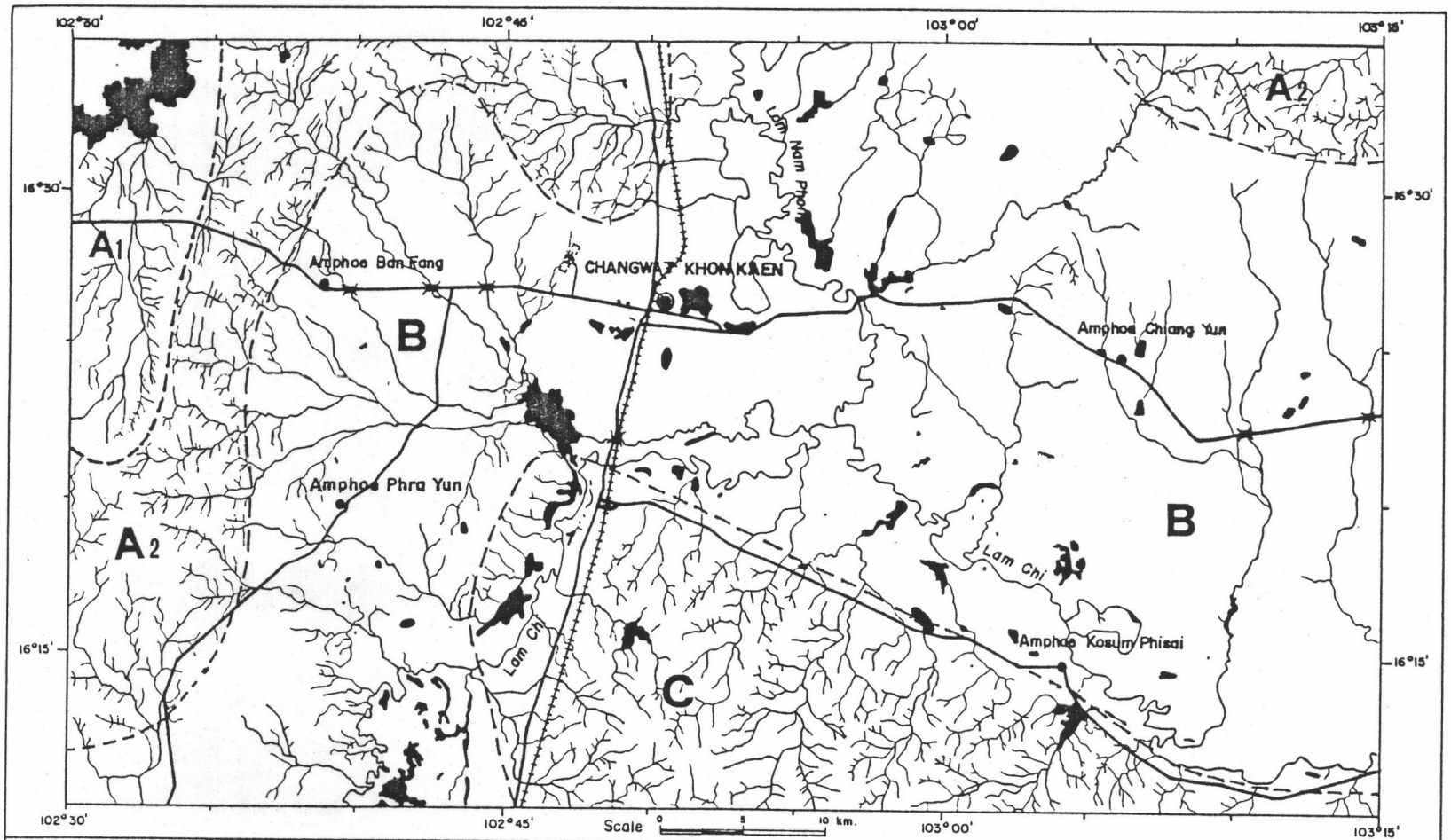
2.2.2 Preliminary Study.

In order to establish keys of interpretation and preliminary interpretation map of the study area and to select representative areas for detailed investigation, existing memoirs and maps together with site investigation reports are extensively reviewed. Lansat-3 imageries of various scales incorporating aerial photographs of WWS project and photo index of the area are observed. To this stage of observations, regional structural and geological features along with landforms, drainage systems and photogeological boundaries are extracted and preliminary interpretation map is established. According to the preliminary interpretation map produced, along with regional structural map and regional geological map collaborated with site accessibility, sample sites for detailed investigations are selected. Stereoscopic study and field reconnaissance programmes are designed. Primary photogeological map is produced after the completion of these observation programmes. Then, the keys of interpretation are established and compiled in forms of photo analysis charts.

Details of the procedures to obtain those above mentioned outcomes are as in the followings:-

2.2.2.1 Revision of relevant maps and reports. Existing geological maps of the Northeast region together with geomorphological maps, soil maps and photolineament maps are intensively and extensively reviewed. Essential data pertaining to the study programme are collected and analyzed. Available existing memoirs and reports on geology and other site investigation are also studied. Relevant information on geology, structural geology, pedology and landforms near by the area are organized (Appendix C.).

2.2.2.2 Landsat imageries observation. Drainage patterns, lineament configurations, regional structural and geological features are observed from selected multiband imageries. Multidate imageries are employed to observe soil moisture conditions. Recognition of geological boundaries and lithologic units are based on those indicated advantages. In addition, image properties such as tone, texture, drainage and vegetation covers can also be used to delineate geological boundaries (American Society of Photogrammetry, 1975, and Lillesand and Kiefer, 1979). To this stage of observations, various drainage patterns delineated from MSS. image band 7 and RBV. image are defined. General properties of rock underlying each drainage pattern are interpreted. Lineaments configurations are mapped from MSS. band 7 imagery together with RBV.imagery. Preliminary geological units and major structures are



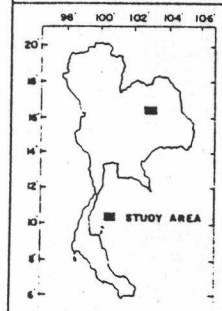


Figure 2.2 Drainage system of the study area, delineated from Landsat-3 imagery (MSS & RBV) of Figure B-2 and Figure B-3.

EXPLANATION

ZONE A1. Moderate density, sub-parallel drainage pattern

ZONE A2. High density , trellis and sub-angular drainage patterns

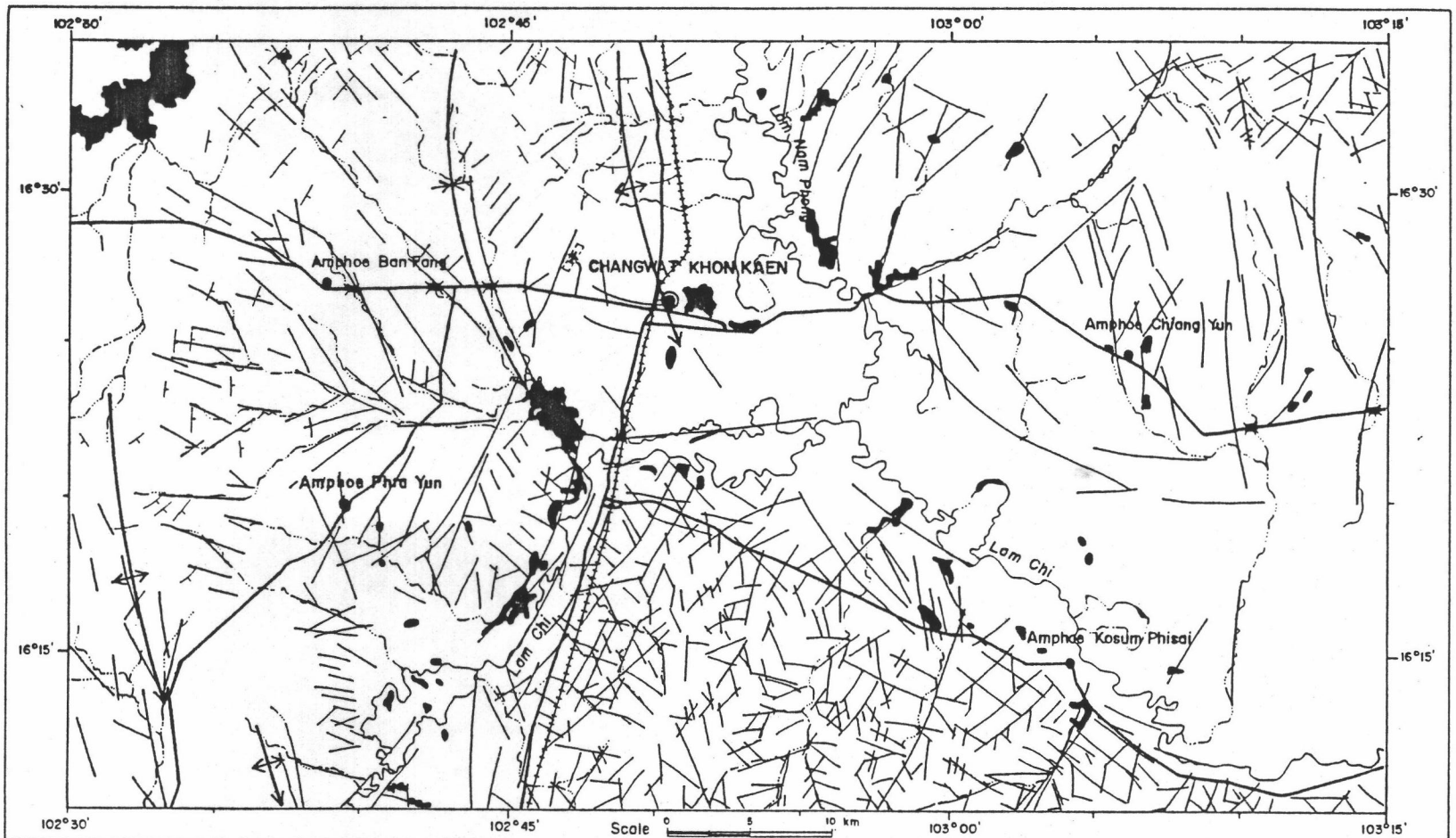
ZONE B. Low density, sub-parallel and anastomotic drainage patterns

ZONE C. High density, sub-angular and trellis drainage patterns

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

Somyot Hokjaroen .

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



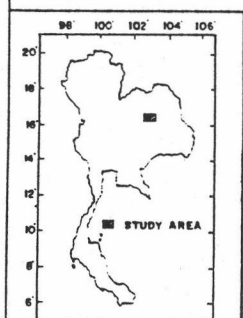


Figure 2.3 Photolineament and folding map of the study area, delineated from Landsat-3 imagery (MSS Band 7 and RBV).

GEOLOGIC LEGEND

Photolineament (fractures)

Bedding trace with low angle dip (5 - 30)

Major plunging syncline and anticline

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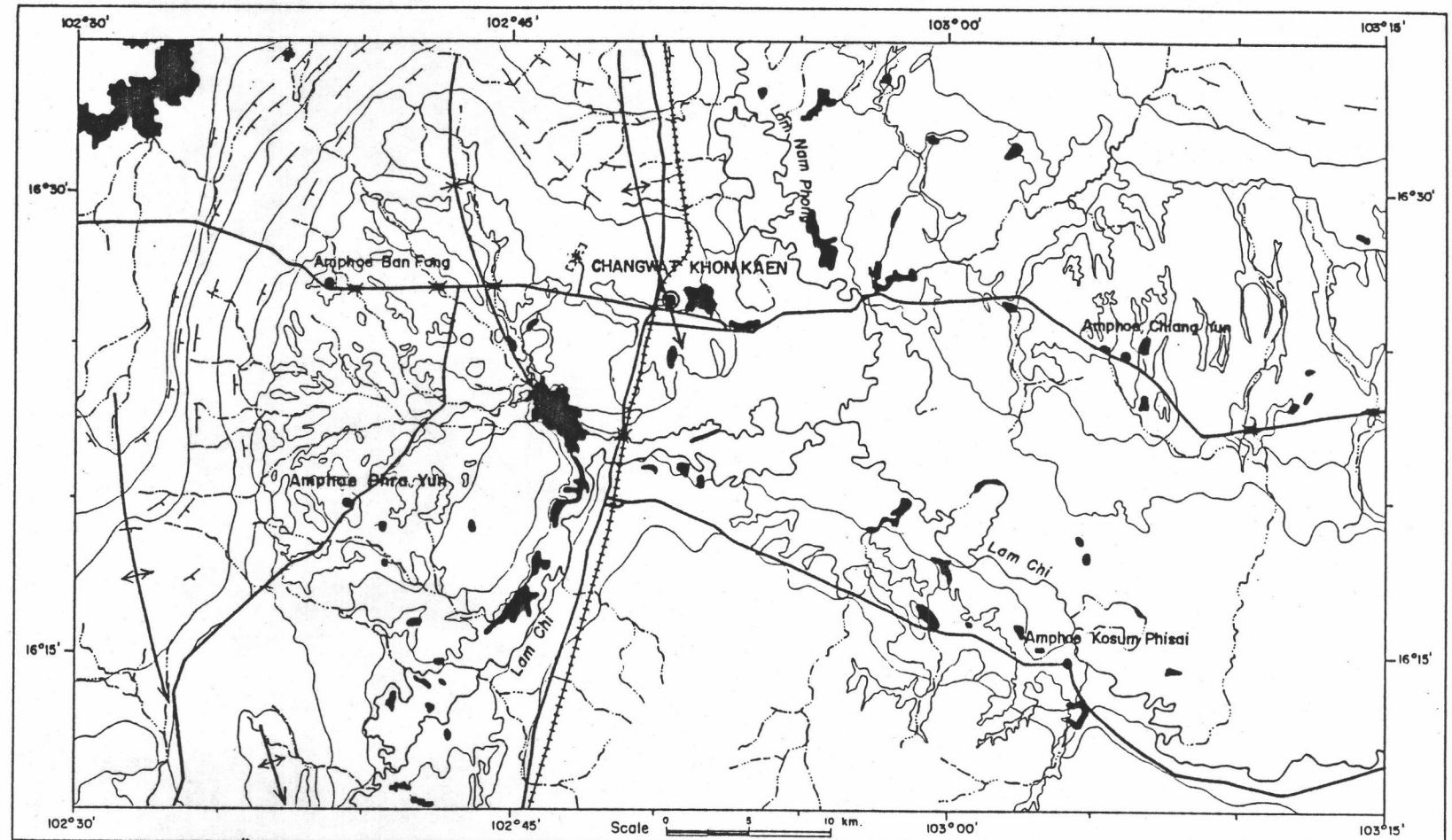

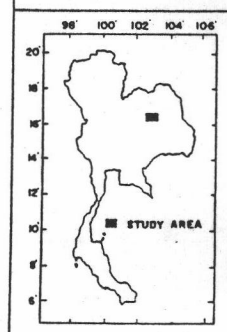

Figure 2.4 Preliminary geological map of the study area interpreted from Landsat-3 imagery (MSS. Band 5&7).

EXPLANATIONS

- Changwat, Amphoe
- Road, Railroad
- Drainage, Water body
- Preliminary geologic boundary
- Bedding trace
- Major structure

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observed and delineated from both black and white, and false color composite MSS images. Those preliminary results are shown on Figures 2.2, 2.3 and 2.4 respectively.

2.2.2.3 Aerial photographs observation. The photo index of priority Area 4, sheet 6 and 7 (Figure B-1) illustrating perspective views of the study areas is chosen. Topographic base map is incorporated in this stage of study. The photo characteristics are used to observe landforms, regional structures, and define geological unit boundaries (Lueder, 1959., Ray, 1960., Miller, 1961., Allum, 1969, and Campbell 1978). The regional interpretation are illustrated in Figure 2.5. To this stage of observation, the thirteen sets of aerial photographs are selected based on appropriate photogeological units, for primary detailed stereoscopic study and spot field reconnaissance (Figure 2.6). The preliminary keys of interpretation in terms of photo characteristics, morphological expressions and geological properties are established and presented to the form of photo analysis chart (Tables 2.1 and 2.2).

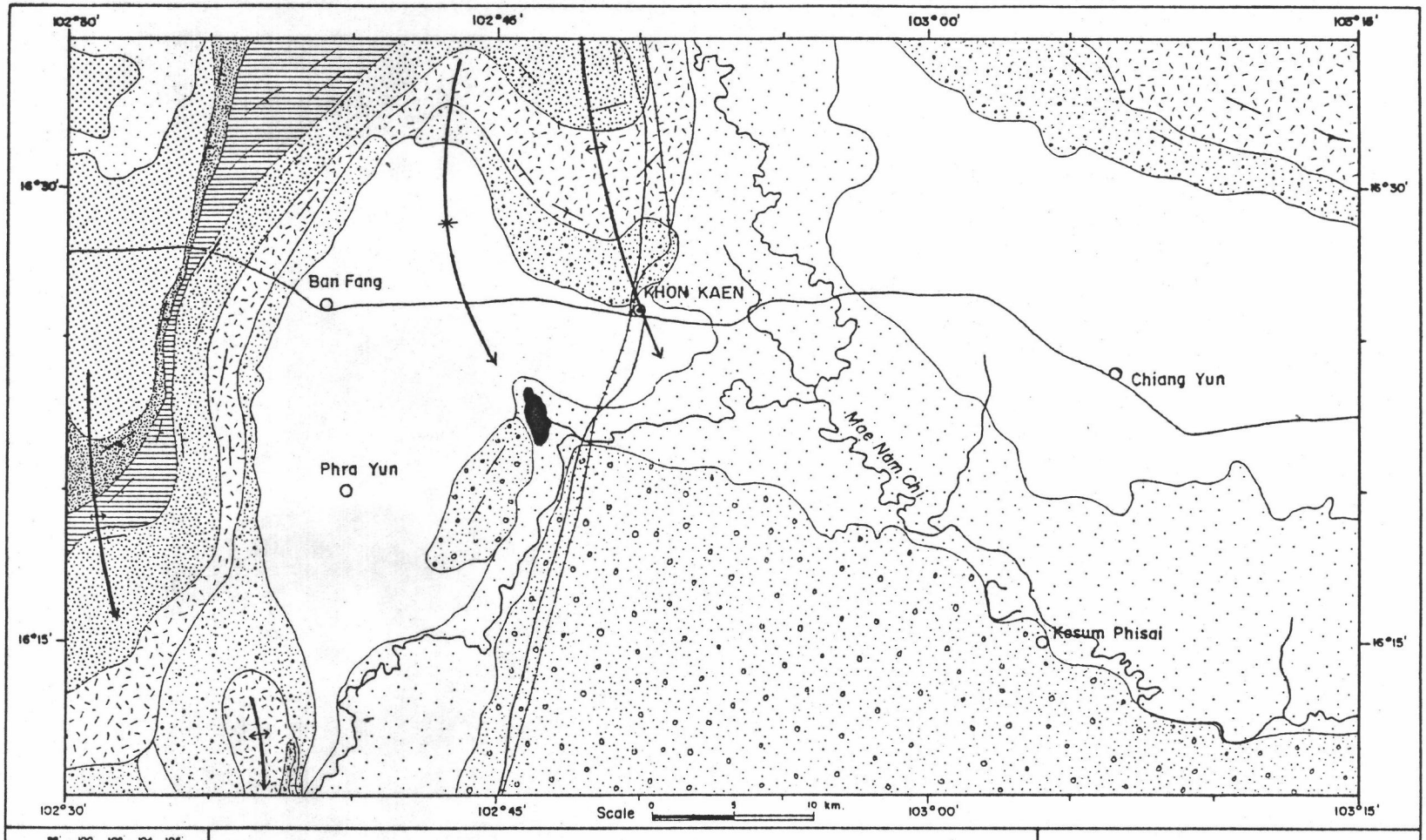
2.2.3 Detailed Study.

In the detailed study stage, the sample selected sites of 13 localities within the study areas are chosen as mapping control locations. The sample selected areas cover approximately 34% of the whole investigation region. The selections are made based on

the representativeness and the presence of all primary mappable units. The presence of rock types and structures that are the key criteria of the area also taken into considerations.

Applying the established keys of interpretation and the mapping procedure developed, the whole study area is interpreted using Landsat imageries and aerial photographs together with topographic base maps. Detailed spot field checks are performed from time to time during the investigation period. More information acquired are added and corrected. Detailed structural and geological information are then organized and grouped. Thickness of each geological unit is also calculated. All the relevant information obtained to this stage of study are then correlated with those of existing geological maps of the area.

The results and findings are concluded and compiled in forms of Photogeological Map of Changwat Khon Kaen and Adjacent Areas. Other thematic maps such as photo lineament map, drainage pattern map, are also obtained. The results of the detailed study will be discussed and illustrated in the next chapter.



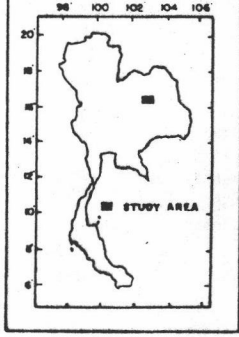


Figure 2.5 Preliminary geological map of the study area delineated from Photo index (Figure B-1).

SYMBOL

- ◉, ○ Changwat, Amphoe
- —, +++ Road, Railroad
- ~, ▰ River, Water body
- Bedding trace
- ⟷, ⟷ Major plunging syncline, anticline

LEGEND
(preliminary photogeological units)

- Q
- M3
- M2
- M1
- E
- D
- C
- B
- A

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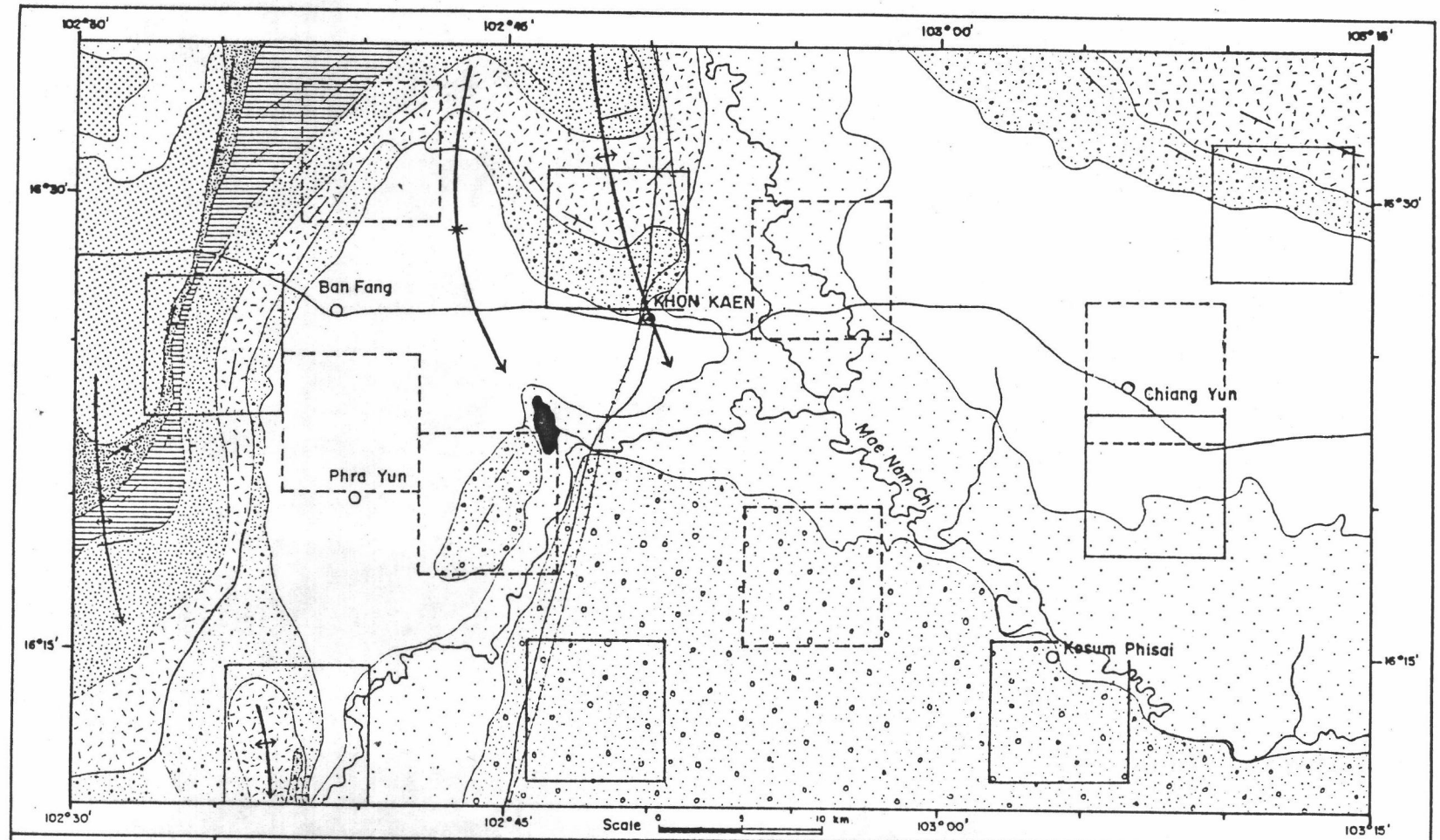

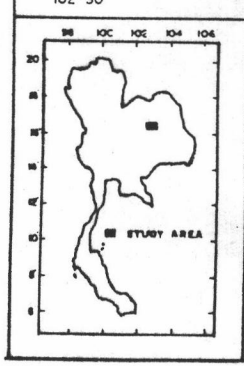

Figure 2.6 Preliminary geological map shows the thirteen selected areas for detailed study.

Initial selected areas.

Additional selected areas.

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Table 2.1 Photo analysis chart (modified after Campbell, 1978).

PHOTOGEOLOGICAL UNIT / SPECTRO-RADIOMETRIC CHARACTERISTIC	Photo Characteristics				Morphological Expressions						Rock Properties					Conclusions
	Tone		Texture		Topography			Drainage								
	Rock & Soil	Vegetation	Rock & Soil	Vegetation	Landform	Vegetation	Land use	Internal-External	Density	Pattern	Resistance	Bedding	Attitude	Jointing	Boundary	

Summary of descriptive terms used in photo-analysis chart:-

PHOTO CHARACTERISTICS

Tone :-

1 = dark
2 = dark grey
3 = medium grey
4 = light grey
5 = light

Texture :-

1 = coarse
2 = fine
3 = band
4 = granular
5 = linear
6 = matted
7 = wolly

MORPHOLOGICAL EXPRESSIONS

[TOPOGRAPHY]

Landform :-

1 = mountainous (elevation > 230 m.)
2 = hilly (elevation 200-230 m.)
3 = rolling-undulating
4 = flat / overlying bed rock
5 = flat / alluvium deposits

Vegetation :-

1 = none
2 = sparse
3 = moderate
4 = dense
5 = scattered
6 = patchy
7 = aligned

Land use :-

1 = forest
2 = improved pasture
3 = upland crops
4 = orchard
5 = seasonal row
6 = paddy fields
7 = abandoned lands

[DRAINAGE]

Internal-External :-

1 = persistent lines
2 = interupted lines
3 = karst phenomena
4 = no surface drainage

Pattern :-

1 = dendritic
2 = parallel
3 = trellis
4 = radial
5 = annular
6 = rectangular
7 = other modified patterns

Density :-

1 = very low
2 = low
3 = moderate
4 = high
5 = very high

ROCK PROPERTIES

Resistance :-

1 = low
2 = moderate
3 = high

Bedding :-

1 = none
2 = massive
3 = well bedded
4 = trace bedding

Boundary :-

1 = sharp
2 = vague
3 = infered

Attitude :-

1 = horizontal
2 = gentle
3 = moderate
4 = steep

Jointing :-

1 = one direction
2 = several directions
3 = not persistent
4 = none

Table 2.2 Summarized photogeological units derived from the study. Numbers represent the descriptive terms as described in Table 2.1.

PHOTOGEOLOGICAL UNIT / SPECTRORADIOMETRIC CHARACTERISTIC	Photo Characteristics				Morphological Expressions						Rock Properties					Conclusions
	Tone		Texture		Topography			Drainage								
	Rock & Soil	Vegetation	Rock & Soil	Vegetation	Landform	Vegetation	Land use	Internal-External	Density	Pattern	Resistance	Bedding	Attitude	Jointing	Boundary	
Q4	5,4	2,1	2	5,1	5	6,7	6,2,7	1,2	2	7	-	-	-	-	-	alluvial deposits, flood plain and associated features along river courses, i.e., levees, oxbow lakes, meander scars, etc.
Q3	2,1	2,1	2	1	5	3,6	7	2	1	7	-	-	-	-	-	alluvial deposits, lakes and swampy areas.
Q2	3,2	2	4	4	3,4	3	3,6,2	3	2	7	-	-	-	-	-	alluvial deposits, development of numerous ponds and small depression features, found along main river course at higher relief.
Q1	4,3	3	4	6,5	4,3	5	6	1,2	2	7	-	-	-	-	-	residual and/or alluvial deposits, overlying the shallow parent rocks, gently undulating to nearly flat terrains.
M3	2,1	2,1	1	1	3,4	4	1,7	2	1	2	2	1,4	1	2	1	sand and gravel deposits, unconformably overlying bedrocks but structurally following with bedrock erosional surface.
M2	2,1	2,1	1	1	3,4	3	6,2,7	2	3	2,1	1	1	-	4	2	sand deposits, mostly surrounded byQ1 unit and show white patch at foot slope, local folding can be traced on small scale image
M1	2,1	2,1	1	1	3	4	1,3	1	4	1,3	2	4	1	2	3	moderate resistant rock unit, high influence of fracturing, rolling area, with dendritic and sub-parallel drainages pattern.
E	4,3	4,3	4	4	3	3	6,1	1	3	3,2	2,1	4,3	2	2	3	alternating of moderate and low resistant rock unit, sub-horiricontal, well developed bedding traces and drainage.
D2	2,1	2,1	1	1	2,3	4	1,2	1	2	3,2	2,3	4,3	2	2	3	high resistant rock unit, elongated hilly terrain with gently bedding traces, drainage generally developed along weak zone.
D1	2,1	2,1	1	1	2,3	4	1,2	1	2	3,2	3,2	4	2	2	3	high resistant rock unit, similar to D2, but relatively more resistant and higher relief, ridge-forming can be observed.
C	3,4	3,4	4	4	3,2	2	6,1	1	3	2,1	1,2	4	2	1	3	low relief and less resistant rock unit, compare to the lower and the upper units, bedding traces frequently noted.
B	3,2	3,2	1,5	1,5	1	3	1	1	1	7,2	3	3	2	1	1	very high resistant rock unit, well developed ridges and escarpment with gently dip slope,highly dissected features appearance
A	3,4	3,4	4	4	3,4	3,5	6,1,7	2,1	3	7,1	1	4	1	3	2	low resistant rock unit, scattered patchy occurred on gently undulating terrain only in the western portion of the study area.