



CHAPTER I

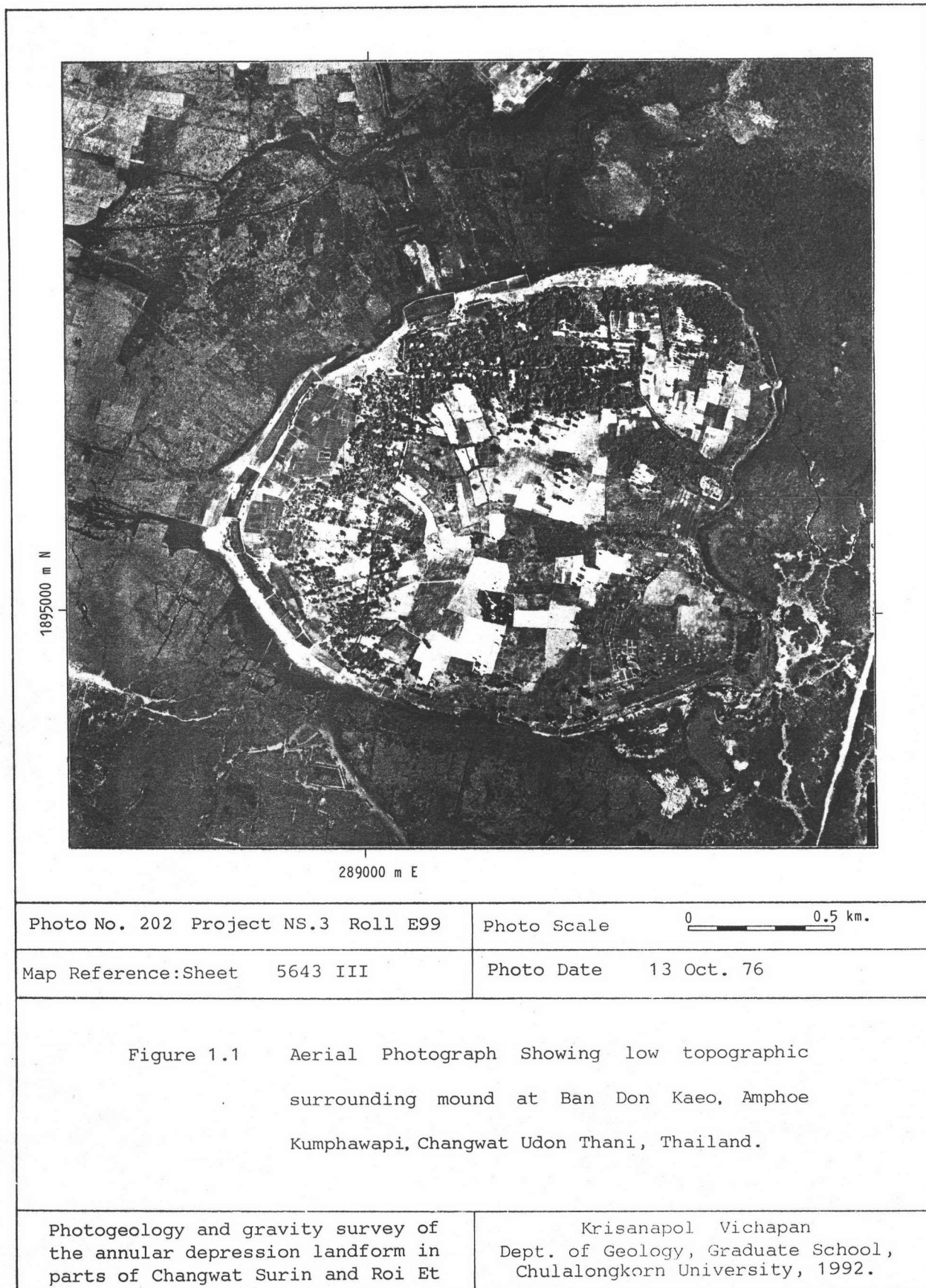
INTRODUCTION

1.1 Background Study.

The unique natural landforms of somewhat circular feature including ring shape depression area enclosing mound of higher elevation, has been recognized on aerial photograph. They are found only in the northeast of Thailand where the terrain is underlain by sedimentary strata interbedded with thick salt layers of Maha Sarakham formation. The terrain are well known as the Khorat basin and the Sakon Nakhon basin.

The landforms of this type were reported to be related to moated ancient settlement. Where the settlements is located on mound and the moat is dug at the foot of the mound within the depression area storing fresh water. They are shallow fresh water sources which can also be found developed for domestically used in recent day (Thiva Supajanya, 1981). According to previous study, they are believed to be the surface expression of shallow salt dome. However, the conclusion was hypothetically made without systematic study to support.

A preliminary study was carried out to observe a similar landform of this type reported on the other part of the world where the terrain underlain by sedimentary strata with salt dome. It is found that they can be correlated. Figure 1.1 shows aerial



photographs at Ban Don Kaeo, Amphoe Kumphawapi, Changwat Udon Thani. The topography is a mound surrounded by depression and was believed to be underlain by salt dome (Rau and Thiva Supajanya, 1985). This feature can be compared to the topography of Avery Island salt dome (Figure 1.2) about 16 kms southeast of New Iberia, Louisiana, USA (Thornbury, 1989). In addition, this annular depression is recommended to be formed superimposed on the "rim syncline" originated during the salt tectonic evolution with the salt dissolving out by underground water. The schematic diagram (Figure 1.3) shows a surface expression of salt dome according to the concept introduced by Seni and Jackson (1983).

The geological study of the landform of ring shape depression found in the northeast of Thailand, thus needs systematic study. The relationship of the topography of ring shape depression and the underlying shallow salt dome can be directly proved by drilling. However, its relatively high cost would made this approach impossible. An scientific approaches should be done through the uses of aerialphoto interpretation and gravity surveyed. It is expected that the result might yields several geological benefits. For academical benefits, it shall lead to the understanding the relationship of ring shape depression with the underlying and the related geologic structure. The relationship might facilitates planning in drilling procedures. And for economical benefits, if the ring shape depression landform is the surface expression of salt dome can be proved, it shall facilitate salt exploration which is the present national economic interests. This might save both temporal and monetary needs for exploration.

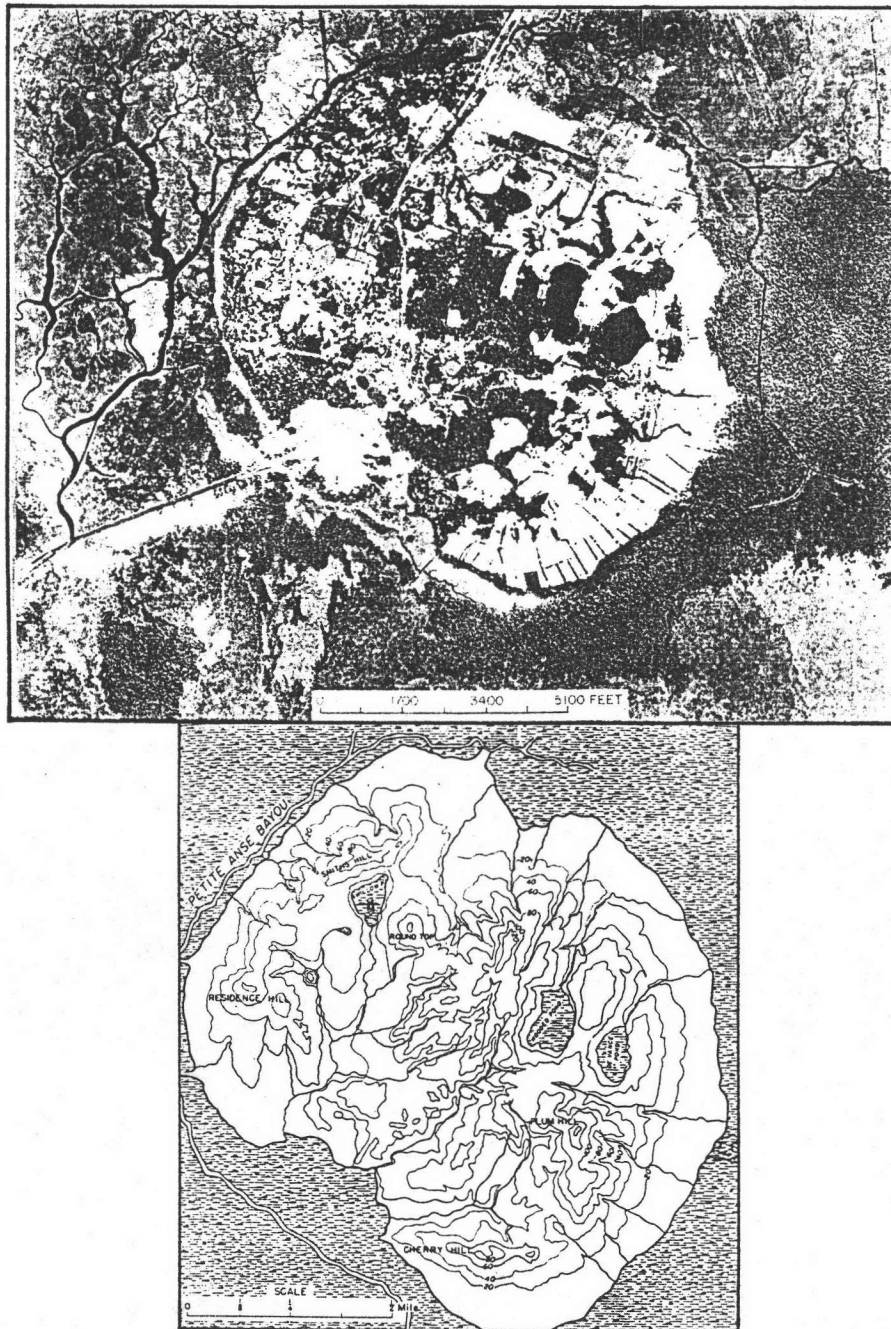


Figure 1.2 Aerial Photograph Showing low topographic around mound at Avery Island salt dome, about 16 kilometers southeast of New Iberia, Louisiana, USA. (after Thornbury, 1969).

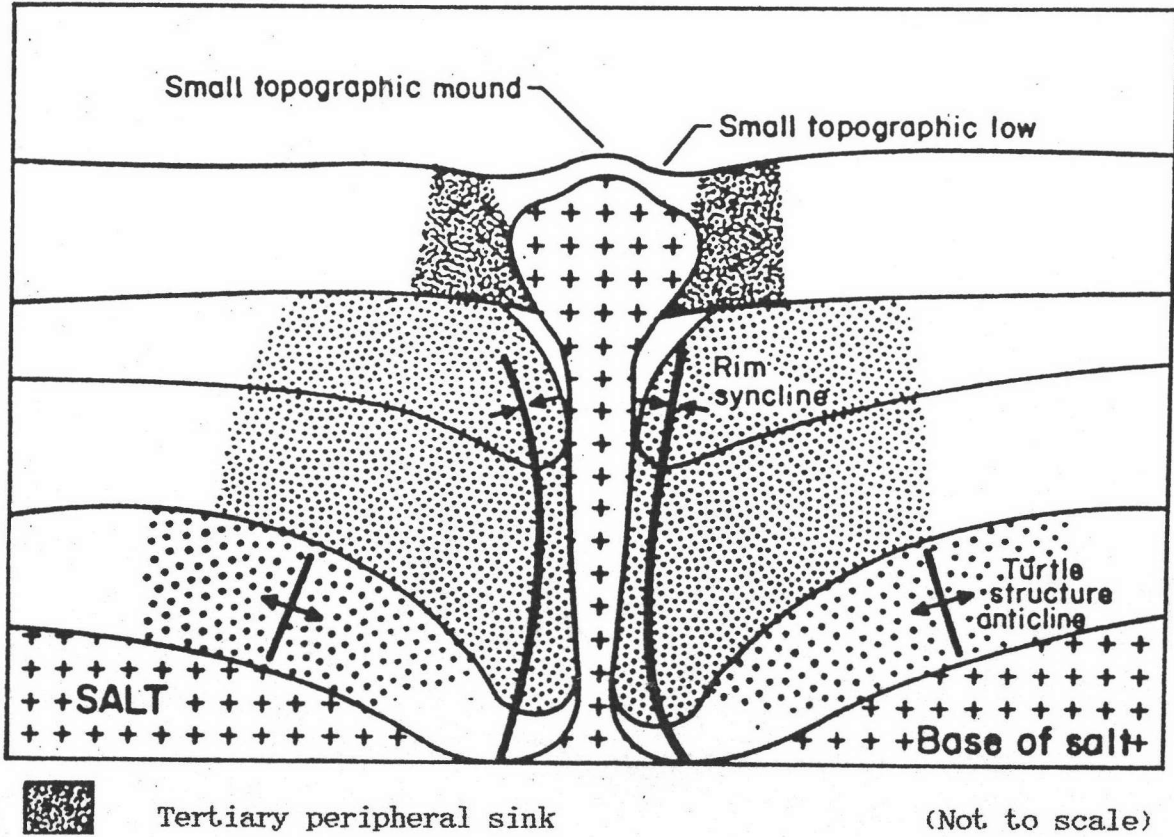


Figure 1.3 Schematic diagram showing a surface expression of salt dome, this annular depression is formed superimposed on the rim syncline (after Seni and Jackson, 1983).

1.2 Objectives.

The overall objectives of this study are as the followings :-

to locate distribution of ADL by using remote sensing image interpretation;

to study subsurface of ADL by gravity survey ;

to study relationship of ADL with local and regional geological structure.

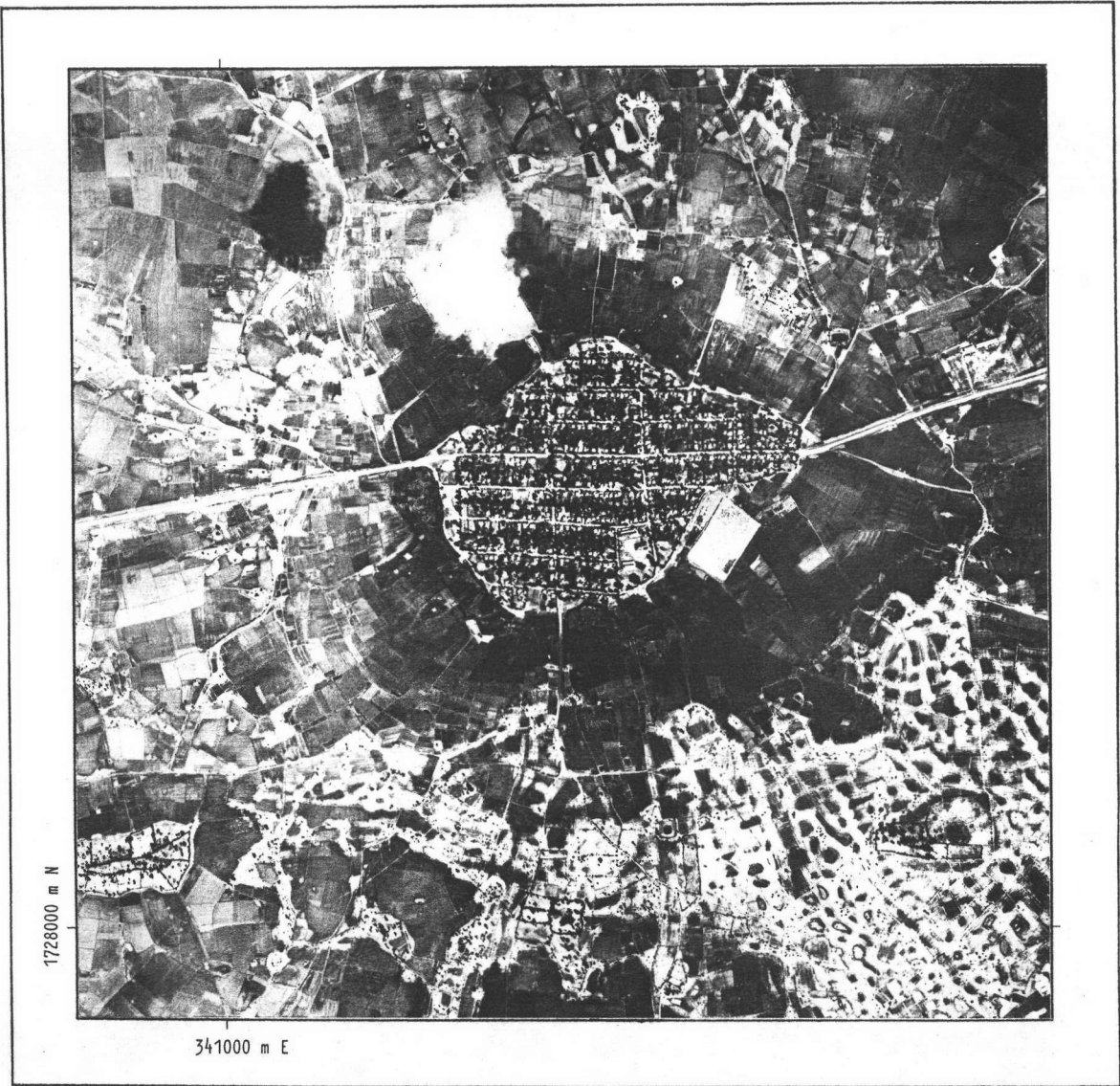
1.3 The Annular Depression Landform.

There is no specified term used for this particular feature manifested on aerial photograph. The term "ADL - Annular Depression Landform" is created with Thai terminology "เอ ดี แอล - ภูมิลักษณะแอ่งขุบวงแหวน", in order to facilitate writing this thesis. An aerial photograph on which the boundary marked to demonstrate ADL is shown Figure 1.4a The elevation profile across the feature is also demonstrated in Figure 1.4b.

"ADL - Annular Depression Landform"

The landform of natural origin having its shape manifested on aerial photograph somewhat of circular feature, including a ring shape depression area surrounding a mound. They are explained as a surface expression of shallow salt dome, and the annular depression is formed superimposed on the rim syncline originated during the evolution of salt dome structure, followed by the effect of underground water dissolving out the salt body.

a)



Elevation Profile of Ban Nam Om

Amphoe Kaset Wisai Changwat Roi Et

b)

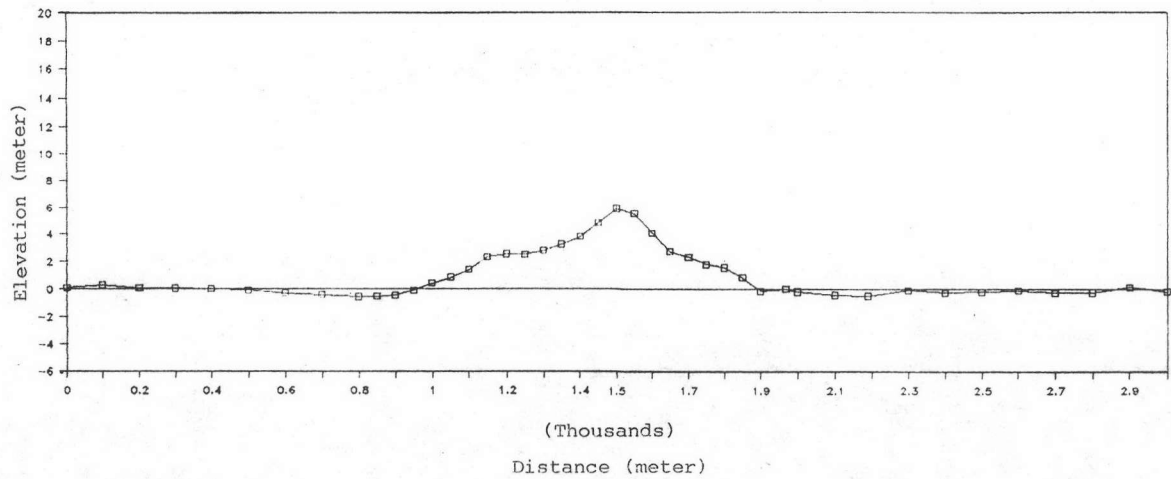


Figure 1.3 Showing Annular Depression Landform of Ban Nam Om Amphoe Kaset Wisai Changwat Roi Et ; a) on aerial photograph ; b) elevation profile.

"เอ ดี แอล - ภูมิลักษณะแอ่งอุบวงแหวน"

ลักษณะภูมิประเทศเกิดขึ้นตามธรรมชาติ ที่มีรูปร่างเห็นบนภาพถ่ายทางอากาศเป็นวงล้อมรอบ ประกอบด้วยบริเวณที่เป็นแอ่งอุบล้อมรอบภูมิประเทศซึ่งเป็นเนิน ภูมิลักษณะดังกล่าวอธิบายได้ว่าเป็นภูมิประเทศที่สะท้อนถึงโครงสร้างทางธรณีวิทยาแบบโดมหินเกลือระดับต้น โดยที่ตัวแอ่งอุบวงแหวนอยู่ตรงตำแหน่งที่ขี้นหินโดมลงแบบกระทะหงายล้อมรอบเนิน ซึ่งเป็นตัวโดมหินเกลือ เกิดขึ้นจากวิวัฒนาการการเกิดโดมเกลือ ร่วมกับการละลายของหินเกลือ

1.4 Study Area.

The study area is located in the area part of the Khorat basin, NE Thailand. It is bounded by latitude $15^{\circ}10'$ to $16^{\circ}30'$ north and longitude $102^{\circ}55'$ to $104^{\circ}35'$ east with an area of approximately 17,255 square kilometers. It covers the area of Changwat Buri Ram, Kalasin, Maha Sarakham, Roi Et, Si Sa Ket, Surin and Yasothon (Figure 1.5). The location of gravity survey (in parts of Changwat Surin and Roi Et) are shown in Chapter 4.

1.4.1 Physiography.

The general physiography of the study area can be broadly recognized and subdivided into two main physiographic groups : undulating - rolling terrain and low land alluvial plain as shown in Figure 1.6 (Somyot Hokjaroen and Thiva Supajanya, 1982). These are classified according to the major characteristics of topography described for the Southern Khorat Plateau.

The undulation - rolling terrain, covering about 70 percent of the study area. It is the main physiographic unit which has the surface elevation between 125 to 180 meters MSL. General

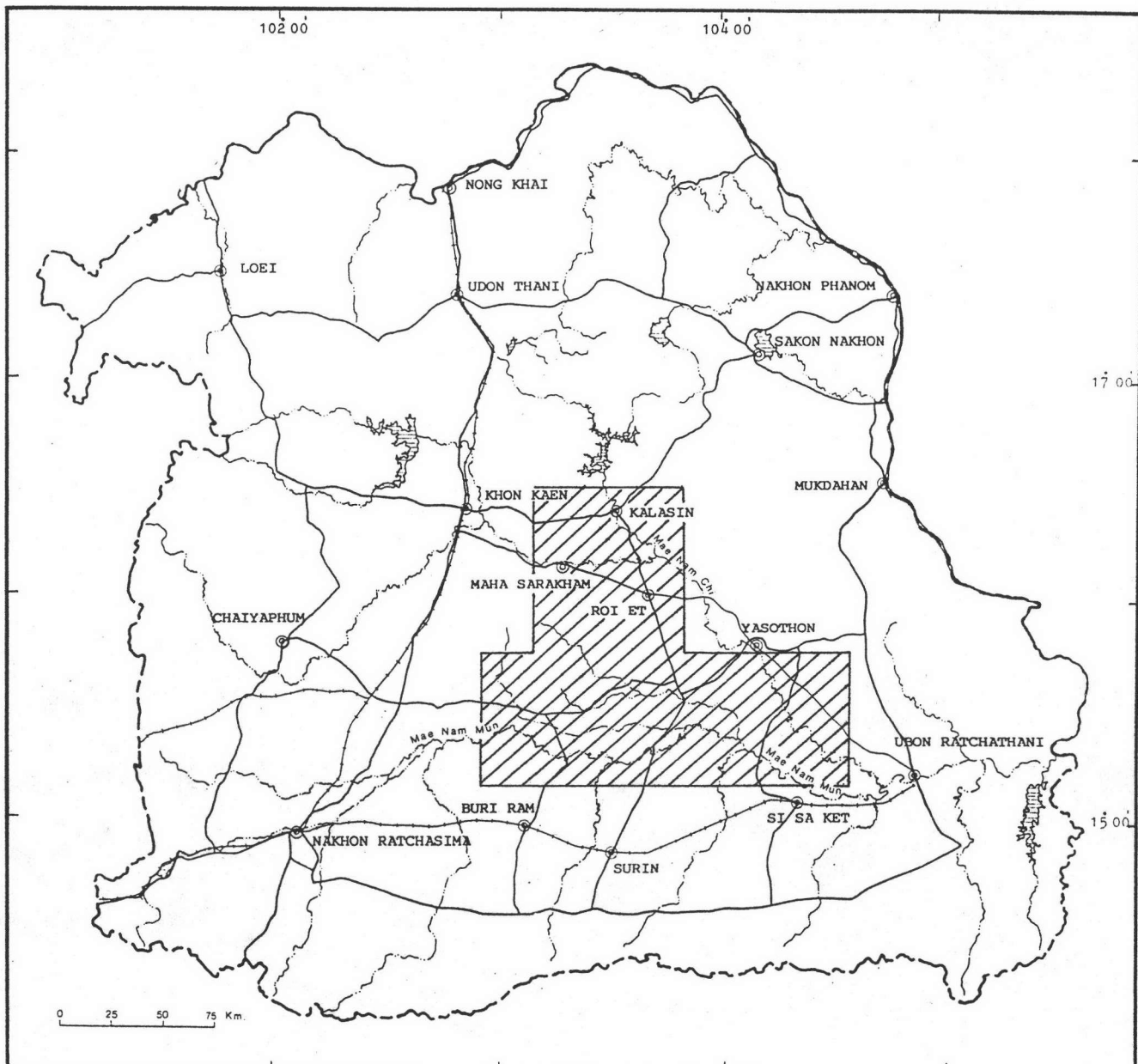
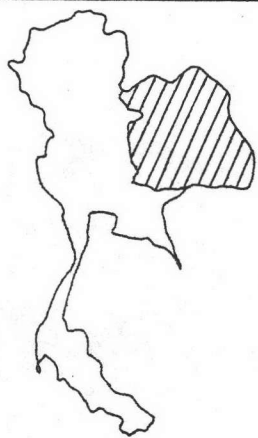


Figure 1.5 Map showing location of the study area.



Explanation

- | | | | |
|-------|-----------|---|---------------------------|
| — | Road | ⊙ | Changwat |
| —+—+— | Railroad | — | Boundary of the Northeast |
| ~ | River | ▨ | The Study Area |
| ⊞ | Reservoir | | |

Photogeology and gravity survey of the annular depression landform in parts of Changwat Surin and Roi Et

Krisanapol Vichapan
 Dept. of Geology, Graduate School,
 Chulalongkorn University, 1992.

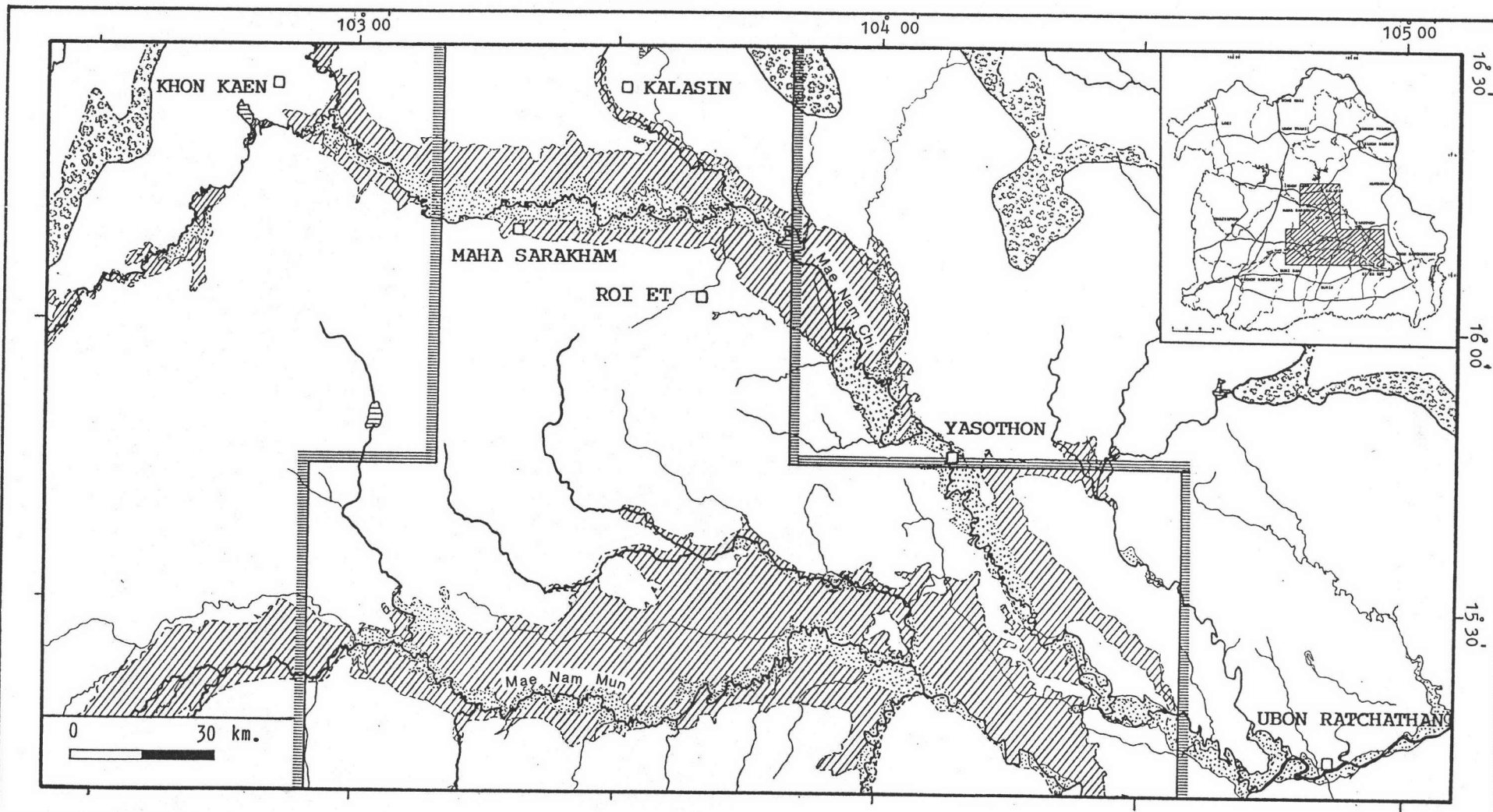










Figure 1.6 General physiography of the study area (modified after Somyot Hokjareon and Thiva Supajanya, 1982).

- | | | | |
|---|----------------|---|----------------------------|
|  | The Study Area |  | Elongate hilly terrain |
|  | River |  | Undulating-rolling terrain |
|  | Reservoir |  | Low land alluvial plain |
|  | Changwat |  | Flood plain |

Photogeology and gravity survey of the annular depression landform in parts of Changwat Surin and Roi Et

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physiographic expressions are more or less monotonous plain to gently undulation 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 Mun, Mae Nam Chi and their numerous tributaries. Mae Nam Mun systems traverse the lower study area and the upper part, is Mae Nam Chi systems. Recent flood plain lies within this low land and can be delineated along the river, natural levees, back swamp deposits and many of oxbow lakes (or 'Kud') along the river courses are formed.

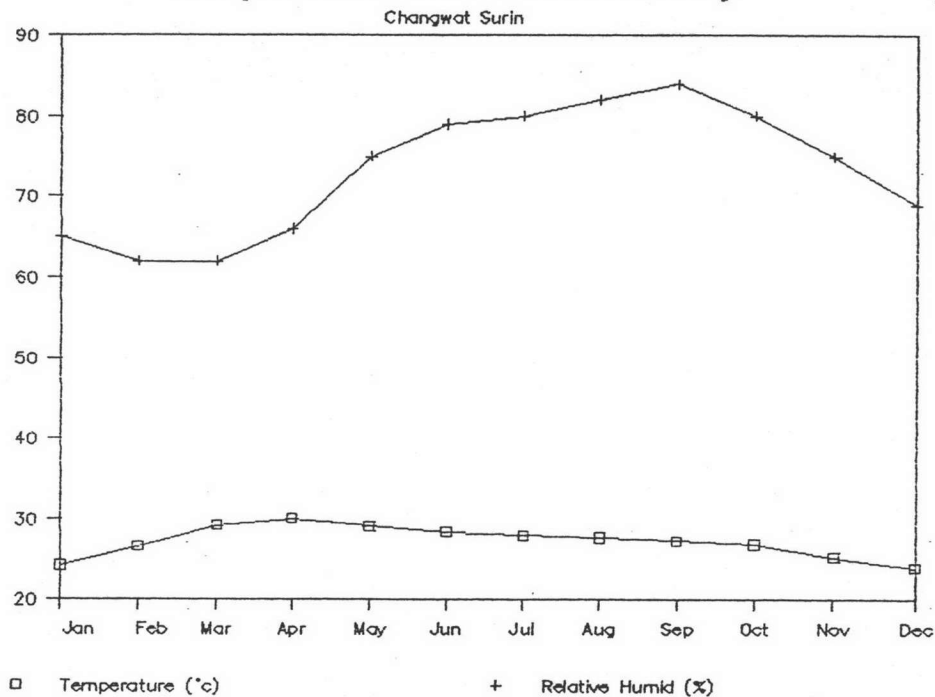
1.4.2 Climate.

According to the Agroclimatological Map (Eelaart, 1973), 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 300 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 northeast monsoon. During February to May, the weather is hot and dry with occasionally rain falls due to the tropical cyclone. The quantity of rainfall, temperature ; evaporation and relative humidity of Changwat Roi Et and Surin are averaged using the data obtained from the Meteorological Department and summarized monthly as shown in Figure 1.7 and Figure 1.8

Temperature and Relative humidity

13

a)



b)

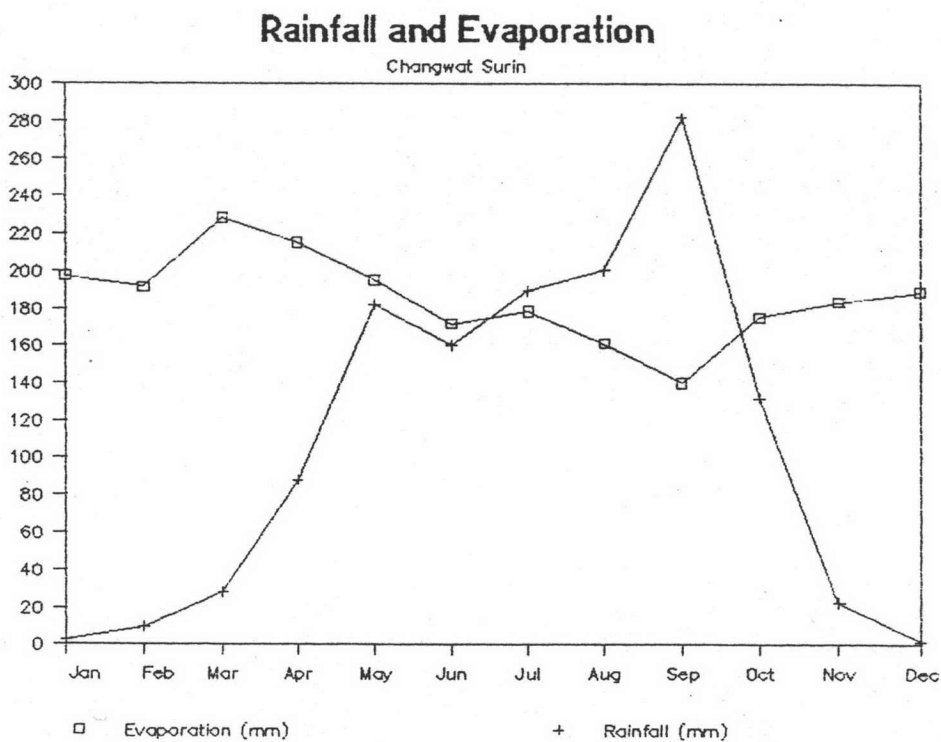


Figure 1.8 Temperature, relative humidity, rainfall and evaporation of Changwat Surin (1951-1980), constructed from the data published by meteorological department, 1982 ; a) Temperature and relative humidity ; b) rainfall and evaporation.

1.4.3 Geological Setting.

1.4.3.1 Geological setting of the Khorat Plateau.

The Khorat Plateau covers a large area of about 170,000 square kilometers. The Plateau comprises of two large broad basins, namely, the northern Udon - Sakon Nakhon Basin (Sakon Nakhon Basin) which covers approximately 17,000 square kilometers, and the relatively larger Khorat - Ubon Basin (Khorat Basin) in the south covering an area of about 33,000 square kilometers. These 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 (Somyot Hokjaroen, 1986). It is elevated with respect to the Central Plain but also bounded in the southeast, the south and the west by a steep terrain and in places mountainous, outward facing escarpment. Its regional topography is undulating to flat and dotted by small hills 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 - Ubon Basin in the south (Figure 1.9)

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 meters. Rocks of the Khorat Group are generally flat lying on gently dipping conglomerate, sandstone, shale siltstone and evaporite.

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 meters thick, 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, Tertiary and Quaternary basalts. The majority of these exposures are

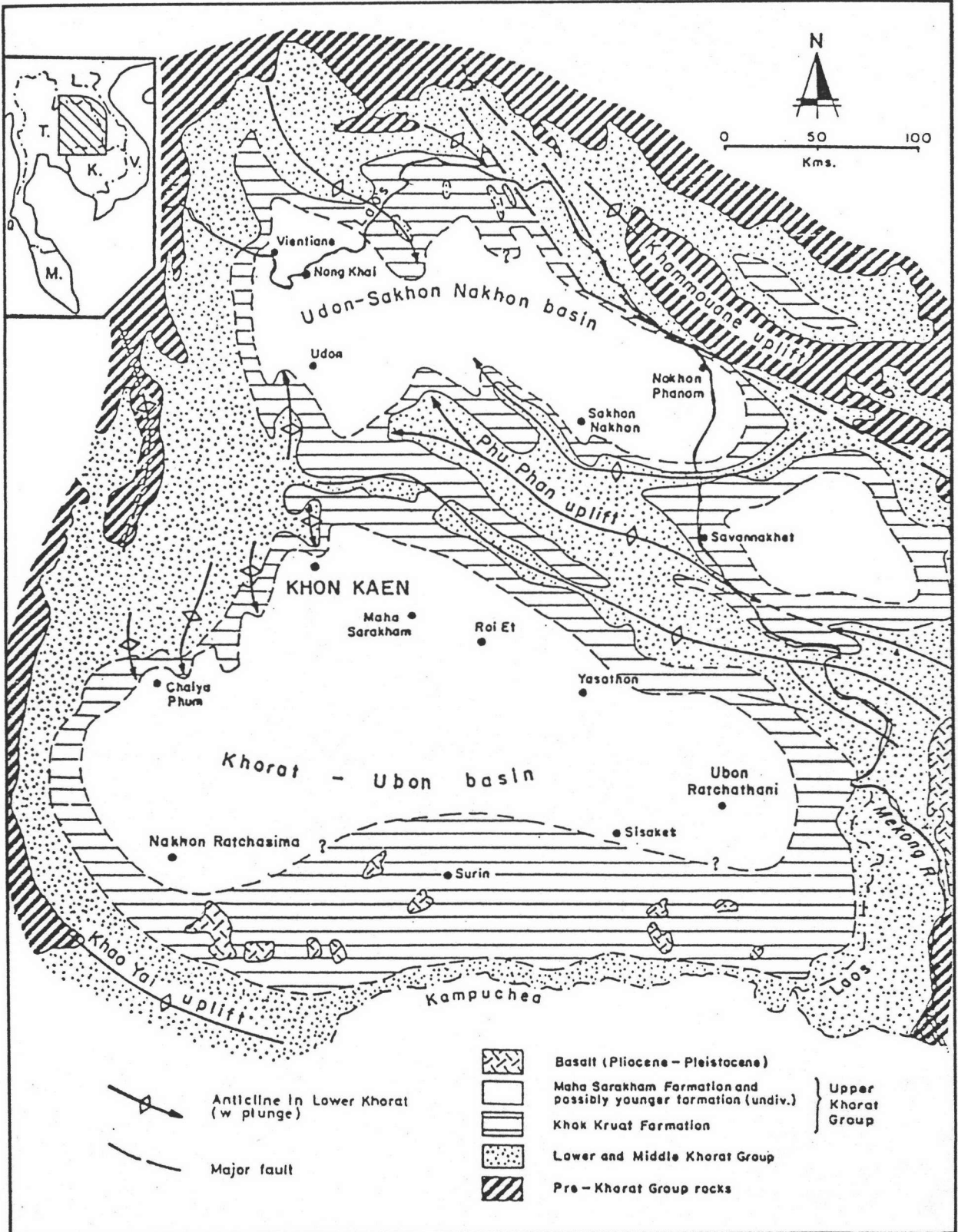


Figure 1.9 Generalized geological map of Northeast Thailand and neighbouring area of Laos (after Thawat Japakasetr and Workman, 1981).

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

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

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 most common type of basalt is the one containing olivine and pyroxene. This is found extensively along the southern edge of the Khorat Plateau. The low-degree of weathering and the relative high quantities of montmorillonite indicated by x-ray diffractograms (Sompob Wongsomsak, 1987) suggest this type of rock to be relatively young.

In Viet Nam, K-Ar isotopic dating and other stratigraphic studies indicate the presence of Mio-Pliocene plateau basalts and Quaternary basalt. Investigations of the Mekong Basin in 1978 ; have subdivided the Quaternary basalts into an old cycle, 1-2 million years and a young cycle, 0.6-0.7 million years. Basalt in the Khorat Plateau, and in the Lampang basin, at 0.69 or 0.95 million years or older, are classified as the young cycle type. However, Sangat Bunopas (1982) reported the basalt to be Late Miocene to Early Quaternary in age. He believed that the volcanic eruptions produced basaltic hills to be a result of a strong tensional episode in Late Cenozoic time. Sompob Wongsomsak (1987) considered that this basalt is Mio-Pliocene.

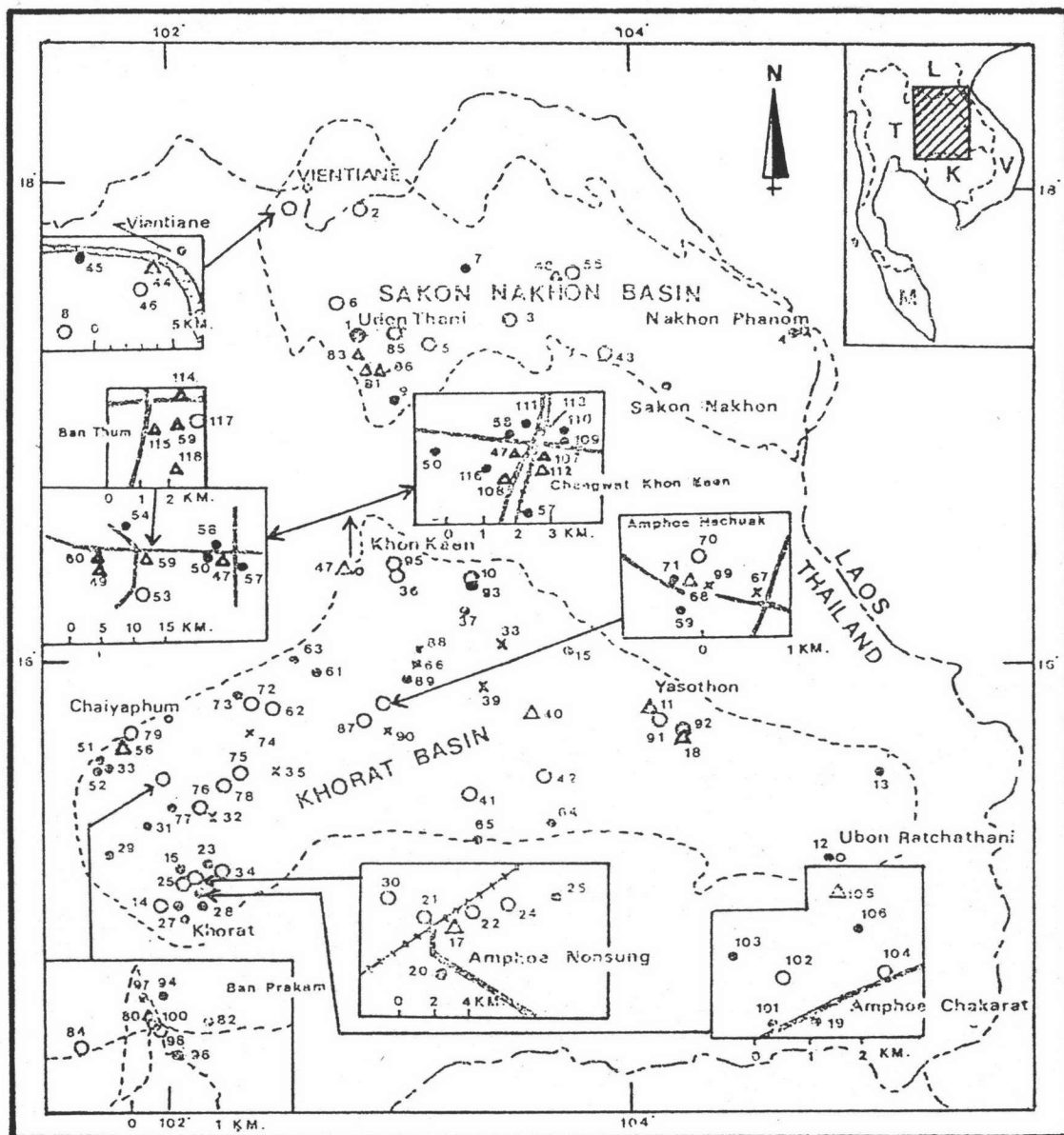
1.4.3.2 Geological setting of the study area.

The geological setting of the study area is relatively simple. It is only composed of the Maha Sarakham Formation and the Quaternary deposits. The Maha Sarakham Formation occupies most of the study area with a typical characteristic undulating topography, where as the Quaternary deposits are mostly covered along the two

major rivers (Chi and Mun).

Currently, many geologists are convinced that the Maha Sarakham Formation should be arranged in Late Cretaceous to Early Tertiary (Pakorn Suwanich, 1986). Following the data from drilling bore holes throughout the Khorat Basin, the successive column of the bedrock forming Maha Sarakham Formation is composed of three rock salt layers interbed with clay and thin layers of anhydrite. They are overlain by interbedded clay, sandstone, siltstone and claystone (Thawat Japakasetr, 1985, Figure 1.10 and 1.11), containing salt bodies ranging in size from small salt veins to large salt dome (Loffler, Thompson and Montree Liengsakul, 1983).

The Maha Sarakham Formation is usually deeply weathered but some surface outcrops do occur in river beds and along road cuts. It is overlain by Quaternary alluvium and mantles of sand of aeolian origin and much of the present day landforms are developed within this veneer of surficial deposits. The landform of the study area has generally been explained in terms of the terrace model. The geomorphological features of the Northeast are predominantly determined by tremendous alluvial deposits of the Mekong River and its tributaries (Moorman, Sarot Montrakun and Somarn Panichapong, 1964). Where by the sedimentation of these deposits has taken place in several phases, each phase of sedimentation being separated by a period of erosion so that the present day landscape composes of four main levels of sedimentation which were called the high, middle and lower terrace and the present day alluvial plain. The maximum depth of the alluvial deposits covering the study area is 150 m.. This has been shown by a seismic profile carried out by Western Geophysics (unpubl.) along the road from Suwanaphum to Tha Tum. It is consist



SCALE 0 50 100 KM.

- Drilled Hole with Rock Salt
- ⊙ Drilled Hole with Rock Salt and Carnallite
- △ Drilled Hole with Rock Salt Carnallite and Sylvite
- × Lower Rock Salt and Potash Horizon did not reach

Figure 1.10 Showing locations maps of potash and rock salt drilled hole in Thailand (after Thawat Japakasetr, 1985).

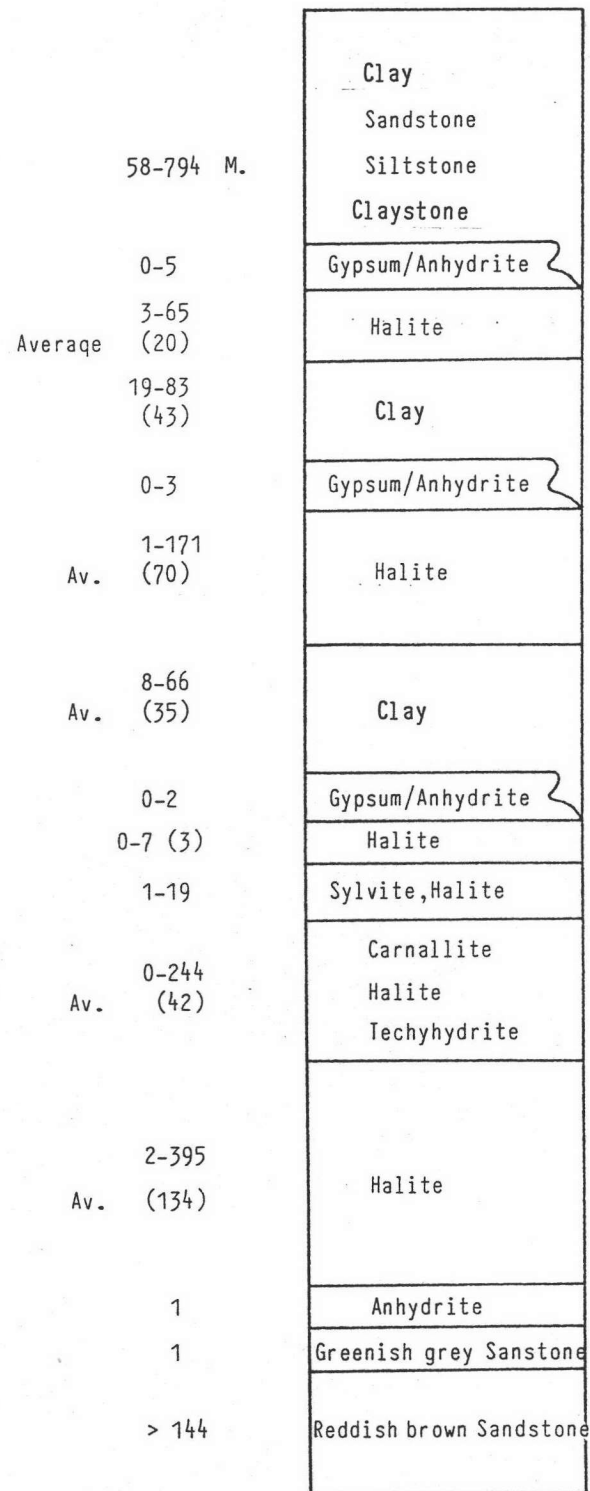


Figure 1.11 Schematic column of Maha Sarakham Formation (after Thawat Japakasetr, 1985).

of six sedimentary unit (Figure 1.12) such as sand of meander belt, clay, non organic sand, organic sand lower non organic sand and Alluvial sediments of unknown composition. The age of the organic sand unit is approximately 34,000-20,000 years B.P. (dated by C-14 dating).

1.4.4 The Study of Salt Structure in the Northeast Thailand.

In the past, there are no the direct investigation about the relationship of the Landforms and the underlying salt structures, however some related researches shall be referred in this paper.

Wallace Lee (1923) studied geology of the Northeastern Thailand reported about the probably of salt layer in subsurface.

Ward and Bunnag (1964) studied the upper part of Khorat Group found that they are consist of siltstone, sandstone, very thick salt layer with Gypsum altogether more than 600 meter in thickness.

Thawat Japakasetr (1985) identified from borehole of Potash's exploration 3 salt layers in Maha Sarakham Formation. The upper layers, about 20 meters thick, is the thinnest layers. The middle layer is 70 meters thick and the lower layer is the most thickest one, it is about 134 meters in thickness.

Pakorn Suwanich (1980) constructed general structures of the Maha Sarakham Formation which commonly composed of salt dome, Salt Ridges, salt anticline, salt basin and salt synclines scattering both in Khorat and Sakon Nakhon Basin. He explained the cause of these salt structures that they are formed by the differential

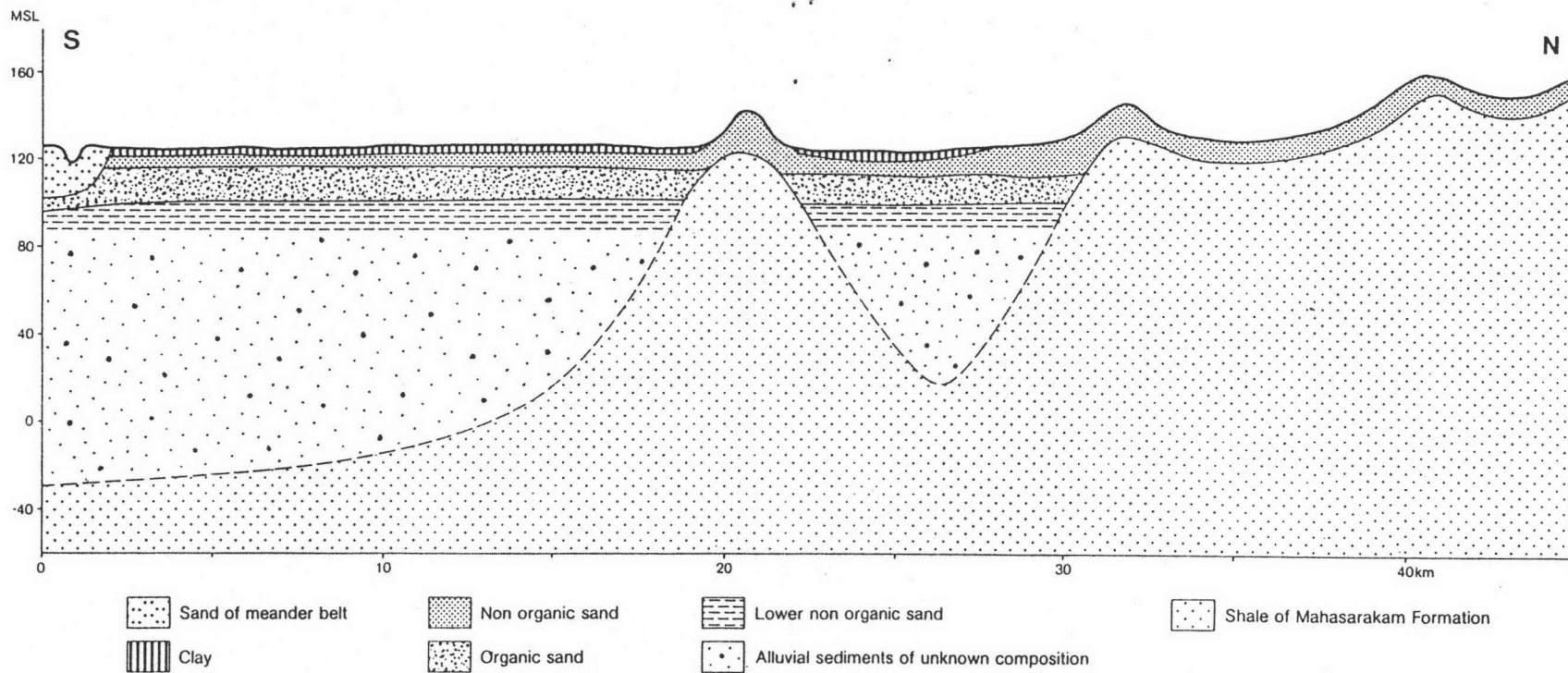


Figure 1.12 Idealized stratigraphic cross section across the study area (after Loffler, Thompson and Montree Liengsakul, 1983).

loading of rocks overlying the plastic salt beds.

By Remote Sensing methods, Thiva Supajanya (1987, 1989, 1992) has found the annular depression landforms associated with the mounds in the middle. From the investigation, these landforms are the fresh water resources and these the relationship of the depressions and shallow salt dome structures can be expected. In addition, this investigation found the landform showing fold structure of salt layers in form of salt pillow, salt anticline and salt dome. At least one of these domes is still active, as shown by radial drainage outward the center.

Somkiet Janmaha (1987) found the character of salt dome from seismic profile and can calculate the size and depth of the salt dome. He found the depths of salt dome at Amphoe Borabu to be located at less than 30 meter under the surface (Figure 1.13).

Nares Sattayasuk and Songpop Polajan (1990) studied the distribution of salt dome from petroleum exploration data and found that salt domes distribute both in Khorat basin and Sakon Nakhon basin.

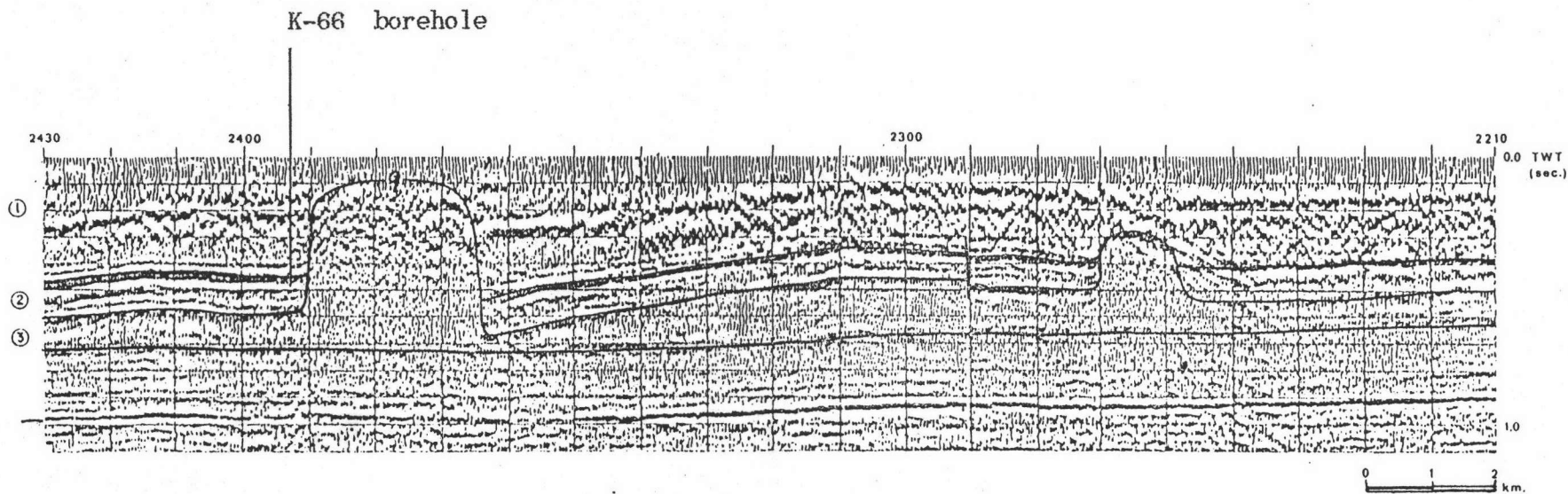


Figure 1.13 Seismic profile showing salt dome in area of Amphoe Borabu (after Somkiet Jammaha, 1987).