CHAPTER 1

INTRODUCTION

1.1 GENERAL

Several small and large scale but isolated intermontane basins, containing thick sedimentary rocks, are known throughout northern Thailand. Few of these basins contain petroleum resources of significant importance (Figure 1.1). Petroleum exploration and exploitation activities in northern Thailand are currently being undertaken at Fang and Phitsanulok Basins. Exploration for oil at Fang Basin (Figure 1.1) dates as far back as the 1920S. Production started in 1950 under the responsibility of the Department of Mineral Resources and a concession was later given to the Defence Energy Department who is at present working in the basin. The total petroleum production from three main oil pools (Chaiprakarn, Mae Soon, Pong Nok, Figure 1.1), during the period 1959-1984, is 1.7 million barrels. At present, the petroleum production rate is approximately 35000 barrels per annum.

The petroleum geology of the basin is fairly well studied. Accordingly, some critical elements of petroleum accumulation such as reservior rock properties, trap types, structural and geologic data, fluid distributions etc. are clearly defined (Settakul, 1985). Habitats of crude oil are mainly the sandstones contained in the fluvio-lacustrine sequences of the Mae Sot Formation. Shallow accumulations within the sequence are accounted for an updip lateral migration of the crudes from deep seated mature facies. The hydrocarbons are characteristically trapped in stratigraphic and structural types (rollover anticlines). Furthermore, the orginal oil

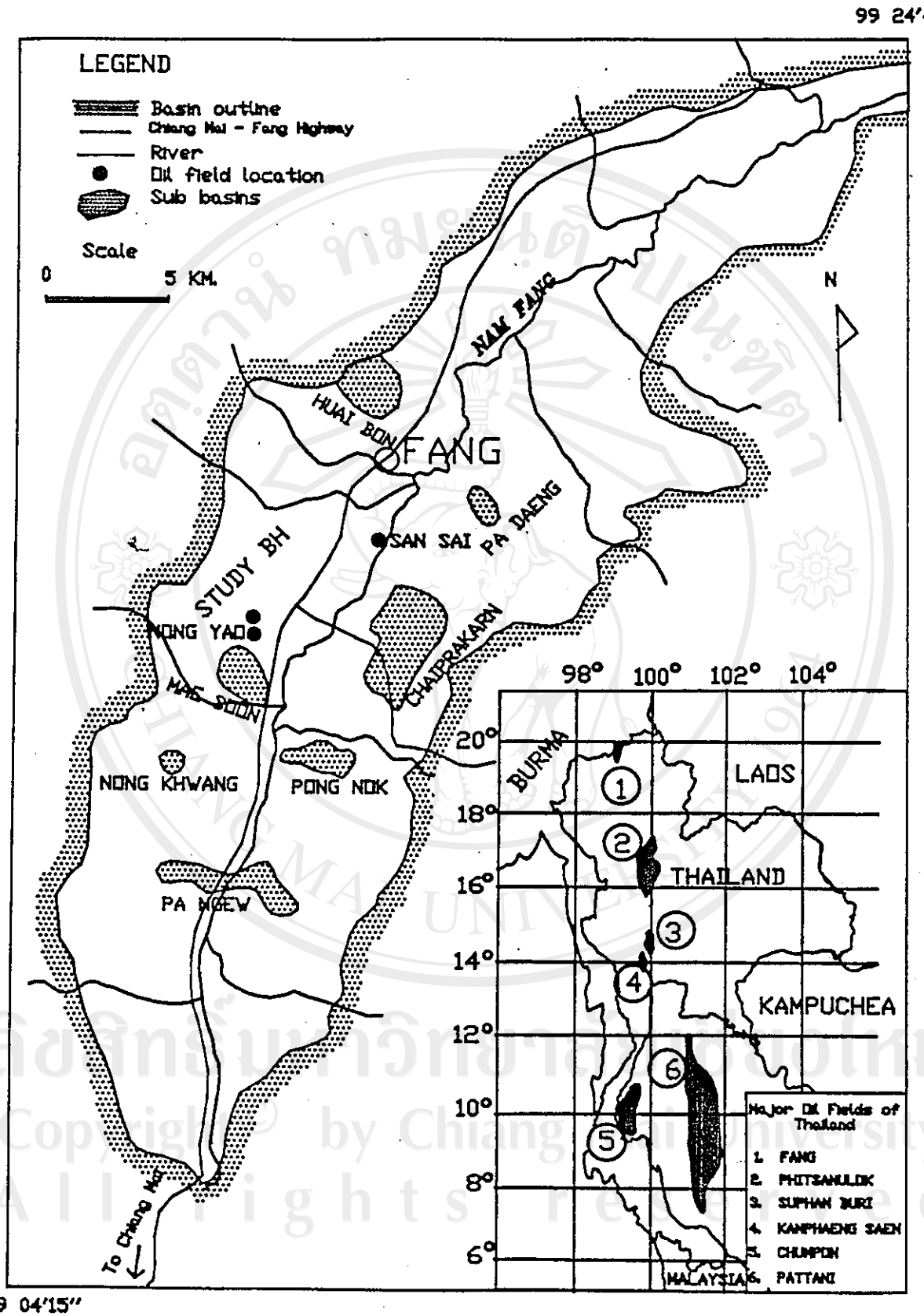

Figure 1.1 Map showing important petroleum exploration /production areas of the Fang Basin mentioned in the text (modified after Khantnaprab and Kaewsaeng, 1987)

in place from two major producing sandstone horizons, VIZ., the Pang Sak and Ang Khang sands, has been estimated at 17.2 and 10 million barrels, respectively (Pompilian and Vasil, 1980; Kulsing, 1984).

Despite all these, there are still some topics which have never been seriously dealt or have only been given little attention. Some of these include source rock studies, age dating, oil generation etc. (Settakul, 1985).

The Tertiary strata in the basin as well as Oil Well IF 30 03S contain considerably thick suite of organic rich lacustrine phases amid the middle and lower parts of the succession. Some of the organic bearing sediments were proposed as probable source strata for oil or gas as suggested by the Defence Energy Department (D.E.D., 1987); Settakul (1985); Khantaprab and Kaewsaeng (1987); Settakul and Pimasarn (1991); and Ratanasthien and Uttamo (1991).

Source rocks are an essential element of any petroleum system. Prediction, recognition and delination of petroleum source units are primary tasks in basin evaluation and subsequent explorations. It is important to recognise these rocks, particularily at the earliest stage of exploration, in order to estimate how prolific the source material has been and get some valuable information regarding the nature of products (oil or gas). There is no doubt that source rock studies on a single well certainly offer valuable information about the quality, maturation and the amount of organic matter in the source rocks. Nevertheless, source rock characterization of a given basin should preferably be based on the study of several wells.

The present study involves a preliminary assessement of the organic rich sediments and the associated rocks based on a set of petrological, geochemical and sedimentological data obtained from Oil Well IF 30 03S, in the western part of the oil field. Palynology of the sedimentary succession has also been studied. Oil Well IF 30 03S was sunk mainly to check for the presence of hydrocarbons in the Mae Sot Formation.

1.2 LOCATION

The Cenozoic Fang Basin occupies the area around Amphoe Fang, in the northern part of Thailand very close to the Burmese border (Figure 1.1). Important petroleum exploration and production areas are also indicated in Figure 1.1. Oil Well IF 30 03S, situated in the western part of the basin (approximately NW of the Mae Soon Oil Field), lies at SP 1130 on seismic line F-6 in Nong Yao structure, at Ban Nong Yao, Tambon Mae Soon (Figure 1.2). The well can be traced on a 1:50,000 topographic map of the Royal Thai Survey Department, Sheet 4848 IV (Amphoe Fang), Series 7017, edition 2-RTDS. The geographic co-ordinate is at latitude 19^{o} 51' 19" N and longitude 99^{o} 09' 49" E. The grid reference is at 17179530.

1.3 PHYSIOGRAPHY

The central lowlands in the basin are approximately 480 m. above mean sea level. The ground elevation of Oil Well IF 30 03S is 486,712 meters (1596.756 feet) and the kelly bushing elevation is 488.93 meters (1604.032 feet). The Mae Fang (Nam Fang) River drains the floodplains in approxi-

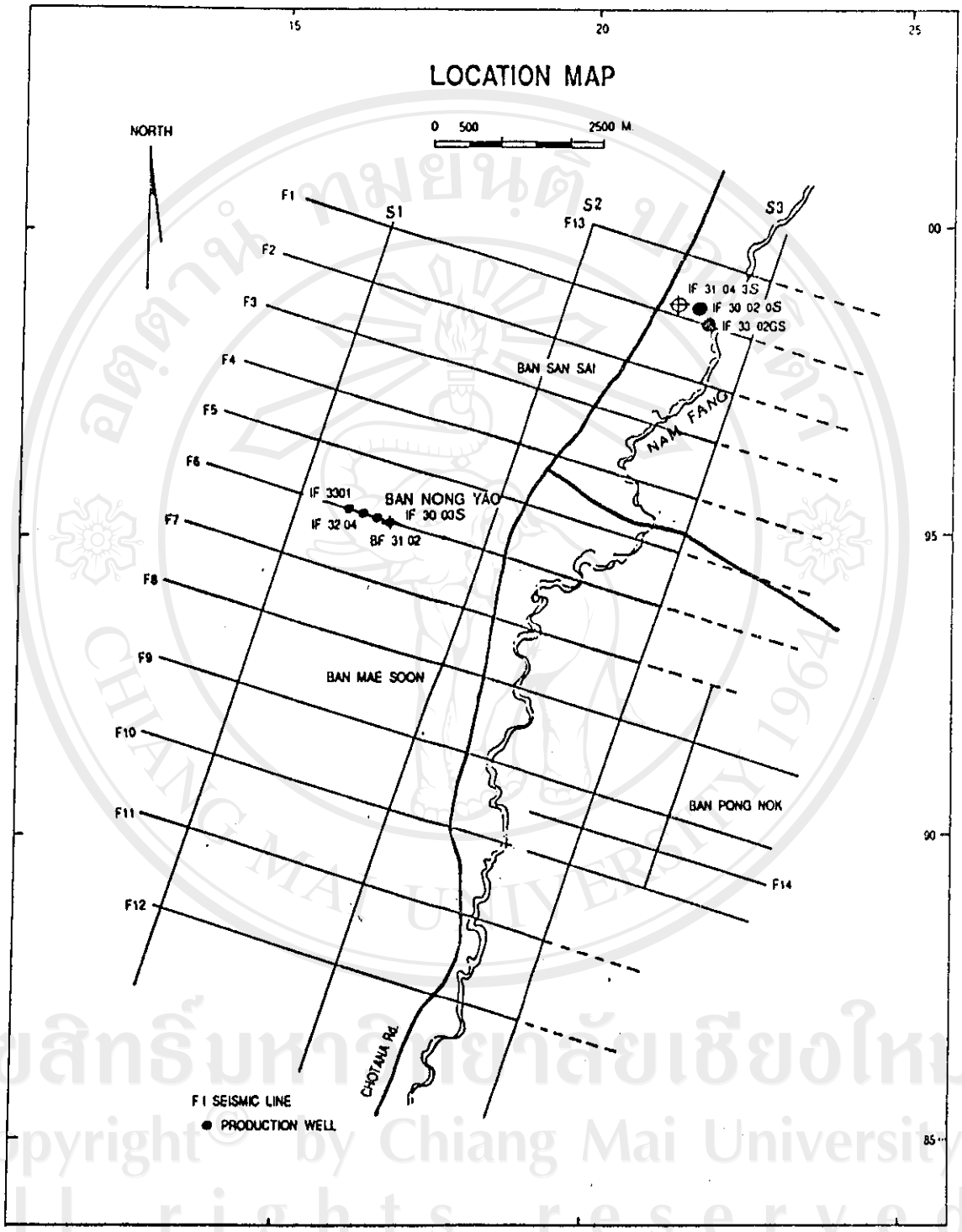

Figure 1.2 Location map of Oil Well IF 30 03S, Ban Nong Yao, Fang Basin.

mately NNE-SSW direction ultimately merging the Mae Kok River; a tributary of the Mae Khong River. The basin is bordered by relatively high mountains, as in the western and southern parts where linear ridges end up abruptly against a rugged mountain range raising upto 1400 m. The eastern side has a relatively low relief. A series of mountain ranges also exist in the northwestern and southeastern sides of the basin.

1.4 SCOPE OF THE WORK

This study mainly deals with the distribution, and characterization of source rocks (in Oil Well IF 30 03S) by integrating several lines of evidences coming from sedimentological, petrological, geochemical and palynological investigations. The sedimentological aspect is concerned with facies and depositional environment studies. The petrological studies are directed towards understanding of the organic and inorganic components of the source rocks. In addition, palynological studies are undertaken and age of the deposit is defined. Preliminary geochemical investigations are also conducted.

1.5 OBJECTIVES

Petroleum source rocks of Oil Well IF 30 03S at Fang Basin are studied with regard to petrology, palynology, sedimentology and geochemistry inorder

(1) To characterise the source rocks in terms of their organic matter assemblage, both quantitatively (abundance) and qualitatively (type) along

the vertical profile using optical microscopic techniques and correlate the result with geochemical data.

(2) To evaluate the degree of thermal evolution (maturity) of the associated organic matter using optical parameters such as vitrinite reflectance, spore color and thermal alteration indices, all of which are obtained from petrological studies.

(3) To study significant petrographic and mineralogical characteristics of the source rocks using thin sections (for texture, sedimentary structures, fossils etc.) and X-ray diffraction techniques, respectively.

(4) To use the palynology of the Tertiary succession inorder to identify the palynomprhic assemblages and evaluate the latter in terms of their stratigraphic, environmental and/or age significances.

(5) To correlate the lithologic and geophysical logs, describe core and cutting samples (of IF 30 03S) inorder to estabilish the lithological succession, subdivide it into lithofacies units and define these in terms of depositional environments.

(6) To assess the type of organic matter using Rock-Eval pyrolysis data; the amount of organic matter based on TOC analysis, and the thermal maturity of the sediments by applying pyrolysis based Tmax and transformation ratio (production index).

1.6 STUDY METHODOLOGY

The generalized scheme (research design) representing the sedimentological, palynological, petrological and geochemical investigations is illustrated in figure 1.3.

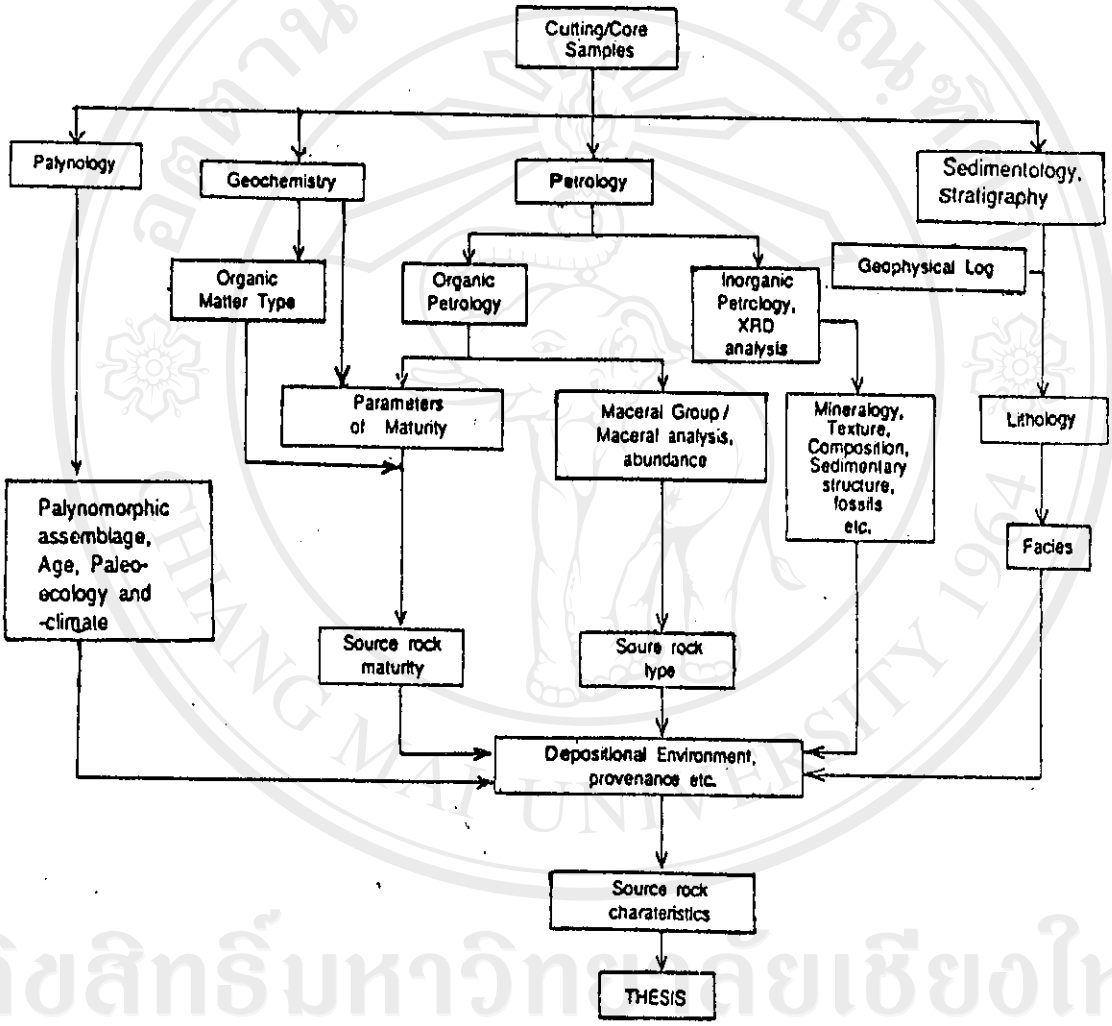

Figure 1.3 A generalized scheme (research design) representing the sedimentological, palynological, petrological and geochemical studies.

Much of the data, which included subsurface information, cutting and core samples and geochemical analyses were exclusively obtained from the Defence Energy Department's geological section at Fang oil exploration site. The geochemical data included Rock-Eval pyrolysis/TOC analyses (on 28 samples), spore color index and vitrinite reflectance measurements (on 7 samples), kerogen composition data (on 7 samples) and solvent extraction analyses (on 2 samples). The subsurface data included both geophysical logs and a stratigraphic column of IF 30 03S. Apart from these, a suite of core and cutting samples were carefully collected throughout the section for palynologic and petrographic studies. All the data obtained were critically examined and used in order to identify, characterize and establish the distribution of source rocks in the vertical succession.

The methods employed in petrological studies are of two types including the organic and inorganic aspects. For the organic petrological study, samples mounted on a cold setting resin and prepared as polished particulate blocks were examined microscopically in accordance with ICCP (1971). Both reflected light and fluorescence mode microscopy were used. Based on these studies, the organic components were identified, described, and the type and amount determined. Moreover, the level of thermal maturity of the sediments was assessed using optical parameters such as vitrinite reflectance, spore color and thermal alteration indices. The type of organic matter was depicted using photomicrographs and the thermal maturity indicators were plotted against depth. The inorganic aspect involved the

examination of thin sections for mineralogy, texture, microfossils and microlaminations. In addition, a number of shale samples were analysed using X-ray diffraction techniques for the bulk as well as clay mineralogy.

The ultimate goal at the interpretation of sediments is the reconstruction of the environment of deposition. This was made possible through the analyses of lithofacies, and their arrangment and association along the vertical profile. The vertical successions in lithology of oil well IF 30 03S are interpreted from wireline logs and wherever possible these were tied to conventional cutting and core descriptions. Commonly two types of logs are widely employed for this purpose, i.e. the electric and gamma ray logs. In a mixed siliclastic sequence, like that of the study borehole, the gamma ray log was readily used to distinguish between sandstone and shale units. Having once established the vertical succession in lithology, the latter was analysed in terms of sedimentary facies and the corresponding depositional environments were defined.

A rapid geochemical assessment of a given well can be conveniently achieved by Rock-Eval pyrolysis and TOC analyses. Rock-Eval pyrolysis and TOC analyses on 28 samples were conducted (by Robertson Research Center) [Table 1.1]. The various parameters taken into account for the present study as regards to pyrolysis include Tmax, Hydrogen index, potential yield, production index and total organic carbon content (TOC). The results of the study provided information about the dispersed organic matter in the samples such as type, amount, level of thermal maturity, evolution stage of the kerogen and source rock potential. Certain guide

Table 1.1 List of hydrocarbon analyses.

	DC
TOC (Leco analyser)	28
Rock Eval Pyrolysis	28
Vitrinite reflectance	7
Spore color index (1-10)	7
Kerogen Typing	7
Solvent extraction	2

lines after Beicip (1988) were used for the purpose of interpretation. The data were presented in the form of geochemical logs plotting each of the parameters against depth. A composite HI-Tmax diagram allowed the visualisation of the type and maturation level of the kerogen. For extended discussions refer to Chapter 6.

The palynological study is based on the examination of demineralised organic concentrates mounted on glass slides, using transmitted light. Wherever possible, fossil spores and pollens were identified, using published materials for comparisons, to the species or genus levels. A number of palynomorphs were systematically described and, in some cases, botanical affinities were given. The latter, together with sedimentological facts, were used in understanding the depositional environments. Furthermore, the stratigraphic ranges of some palynomorphs were presented in a range chart. Age approximation was made on the basis of some age diagnostic palynomorphs. Photomicrographs were taken with a photomicroscope, in a bright field, using a X 100 oil immersion objective and most of the specimens were figured at a magnification of X 1000 (unless and otherwise specified).

1.7 PREVIOUS WORK

Several studies related to the stratigraphy, geologic and tectonic evolution, depositional history of the sediments and petroleum geology of the basin have been reviewed by various workers. Only those which are thought to be quite relevant to this study are summarised below.

Khantaprab and Kaewsaeng (1987), broadly subdivided the Cenozoic sequence into three main successions. The lowermost sequence, representing alluvial fan and meandering fluvial facies, is characterised by medium-coarse grained clastics. The fluvio-lacustrine facies of the middle succession comprises of fine-medium grained terregenes and some coal beds. The uppermost sequence is composed of high energy fluvial facies of braided system and alluvial fan sediments with ephemeral lacustrine deposits. Detailed facies study by the same workers characterises the sequence as surfacial top soil and terrace deposits, fluviatile of braided system/ fluvio-lacustrine, lacustrine/fluvio-lacustrine, lacustrine, coal swamp, lacustrine, and fluviatile of meandering system in descending order.

Settakul (1985) describes the Mae Sot Formation (the lower part of the Cenozoic succession) as representing a fluvio-lacustrine facies and/or possibly a nearshore deltaic facies with marine incursion. The lowermost part of the Mae Fang Formation is considered as representing a fluvio-lacustrine sequence deposited in an oxidizing condition, whereas, the upper part of the sequence is an energetic alluvial and fluviatile facies typical of tropical zones.

Age studies were mainly based on palynology partly for the lack of suitable fossils for dating. Few of the available age studies are summarised as follows :

i) Baum et al. (1970) assigned a Miocene-Pliocene age for some lignite samples.

ii) Buravas (1975) reported six genera of spores and pollens from shale cores which were identified as *Micro-henerici, Corphaeus, Henrici,*

Salix, Pollenties Fallax, Pinus Hapoxylon suggesting an Oligocene-Miocene age for the Tertiary sediments.

iii) Ratanasthien and Haraluck (1987) identified a number of spores and pollens from Mae Soon and Pong Nok oil fields. The results of the study were divided into two palynologic zones : the *Magnastriatite howardi* and *Verrucatosporites usmensis* pantropical zones. They placed these zones in the Oligocene to Lower Miocene and Upper Eocene ranges, respectively.

iv) Watanasak (1989) studied the mid Tertiary palynologic assemblages from four basins in Thailand and estabilished two regional palynological zones referred to as Siam-1 and Siam-2. Two oil bearing intervals from borehole IF-16 (Mae Soon oil field) fell within the Siam-2 zone of late Early Miocene age. Siam-2 zone is characterised by abundant tropical taxa and few temperate types.

v) Organic bearing formations in Thailand were subdivided into the Li and Mae Moh Groups, based on distinctive palynomorphic assemblages. A break in organic accumulation, quite evident in palynomorphic changes, following significant tectonic events in Early Oligocene, was reported by Ratanasthien (1988) from the Fang Basin and Mae Tun coal field.

In general, thick sequences of lower-middle Miocene lacustrine deposits, bearing abundant organic matter are thought to be excellent petroleum source rocks in some of the intermontane rift basins. The petroleum source rocks of Fang Basin are considered to be of lacustrine and/or of fluvio-lacustrine origin. By applying Lopatin's method, the

petroleum is expected to have been generated within approximately a depth range of 1100-1400 m., since late Miocene (Khantaprab and Kaewsaeng, 1987).

Recently, source rock studies by Settakul and Pimasarn (1991) on two wells (IF 30 01G and IF 30 02S) indicated the source strata as being deep seated algal lacustrine shales. Geochemical analyses on few candidate shales revealed the source rocks as comprising of Type II kerogens and as having organic carbon (TOC) ranging from 1.12-2.3 % (IF 30 01G) and 2.09-3.03 % (IF 30 02S). The shales were rated as being highly oil prone but too thermally immature for significant oil generation.

Ratanasthien and Uttamo (1991) studied few coal samples from Wiang Haeng deposits using coal petrographic method. Results of the study indicated that the coals are mainly sapropelites rich in alginites (both lamalginites and telalginites). They suggested that facies equivalents of the Wiang Haeng coals at Fang Basin could possibly be source rocks for petroleum of similar evolution.