CHAPTER I

INTRODUCTION

Generally, a sedimentary basin may be defined as "an area in which sediments accumulate during a particular time span at a significantly greater rate and so to a significantly greater thickness than in the surrounding area". The sediments accumulated by virtue subsidence. The nature of sediments that accumulate in a sedimentary basin is related to environments of the physiographic basin from which the sediments were derived and in which they were deposited. In addition, sedimentary basins may be deformed by faults and folds while they accumulate sediments and sedimentary column is still subsiding.

Stratigraphic record represents the history of processes and events that occurred at surface of the earth. The lithostratigraphic analysis of any sedimentary basin primarily concerns with the fundamental concepts of tectonics and sedimentation. Therefore, any consideration of the history of a sedimentary basin implies the understanding of concepts regarding depositional environments, paleogeographic setting, structural framework and present solid geometry of basins.

Numerous studies on the sedimentary basins have been essentially motivated by the exploration and

exploitation of geological resources associated with sedimentary sequences. These resources are fossil fuels, groundwater, and some industrial minerals. Among all sedimentary basins of different geological ages, Tertiary sedimentary basins appear to be the most attractive. This is basically due to the fact that the production of crude oil from Cenozoic rocks shares almost 60 per cent of the total production as compared with those of approximately 25 per cent from Mesozoic rocks and aproximately 15-18 per cent from Paleozoic rocks. Besides Tertiary sedimentary basins are relatively shallow and have undergone relatively less intensive tectonic deformation which are therefore enable the geological resource exploration and exploitation be carried out much more economically. As a consequence, a great wealth of geological information on Tertiary basins has grown tremendously.

Considering the state of the art on Tertiary geology of Thailand, it can be generally concluded that overall picture is limited and poorly defined. This is essentially due to the fact that almost all of sedimentary sequences belonging to this era are scarcely exposed. They are overlain by Quaternary deposits in numerous intermontane basins in the northern, western, and southern parts of Thailand, underlying the central plain, submerging in the Gulf of Thailand. Therefore, any attempt to investigate the Tertiary deposits is inevitably

undertaken from the subsurface geological and geophysical data and information obtained from the drilling and geophysical exploration.

Amongst over thirty intermontane basins in the northern Thailand which can differentiated and named according to their geographical locations, the Fang basin is one of the important ones. Petroleum have been discovered in this basin for over a century, and exploration as well as the production have been continuously undertaken for over 50 years. Despite the fact that Fang is the petroleum-bearing basin, the geological knowledge of this basin is limited and not fully understood. At present, there is a need of domestic petroleum resource to meet the ever-increasing demand of energy. Therefore, the petroleum resource within the Fang basin has to be reassessed for future exploration and development programmes. The geology of the petroleum is largely the geology of sedimentary basins because it is in the sedimentary basins that the commercial accumulations of petroleum occur. It is therefore essential to have a clear idea from the outset of what a sedimentary basin is.

1.1 The Study Area

The Fang basin is located in the northern part of Changwat Chiang mai (Figure 1.1.a). The basin lies approximately between latitudes 19° 50' to 20° 00' N., and between longitudes 99° 10' to 99° 21' E., occupying

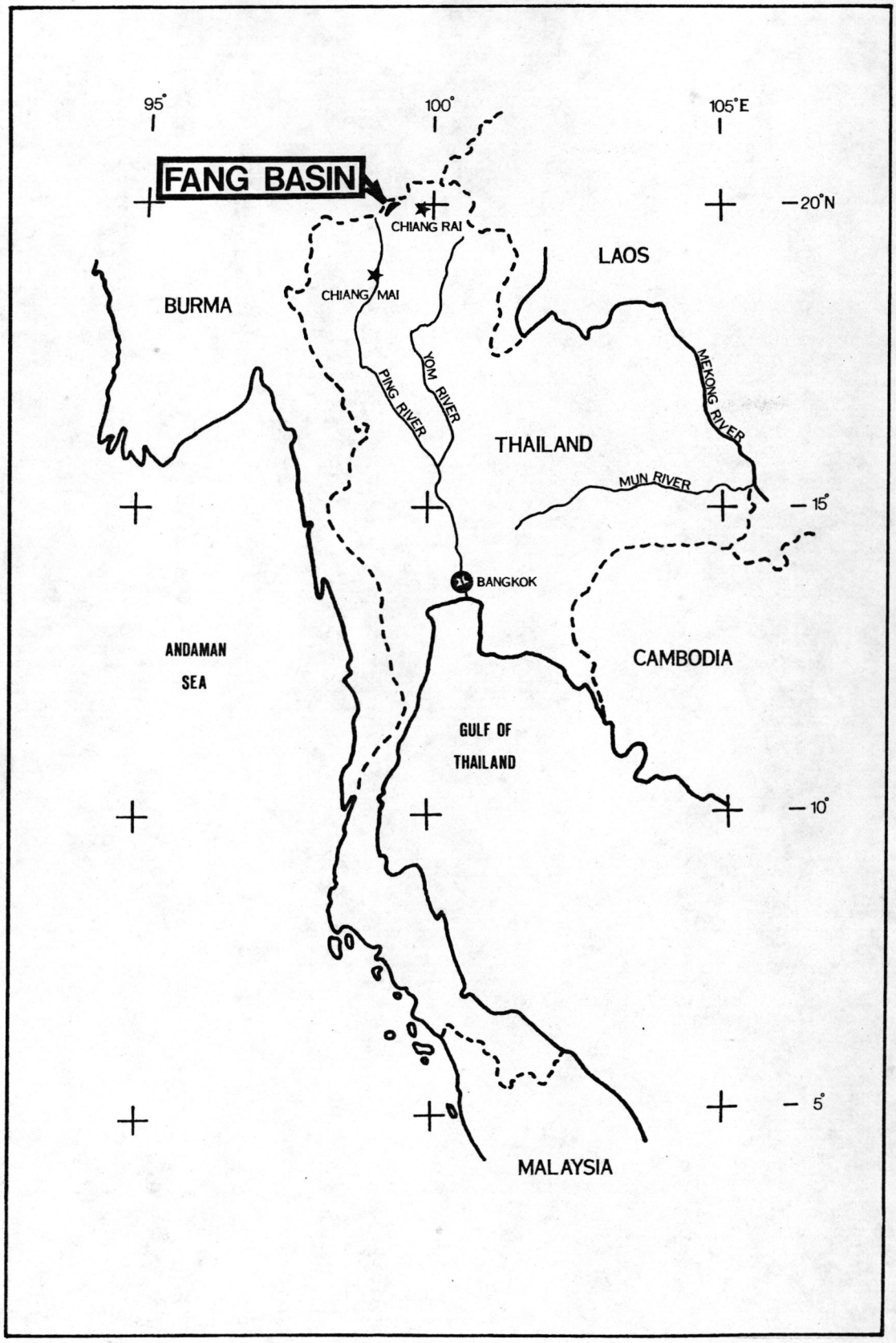

Figure 1.1.a Index map of the study area.

approximately 575 square kilometers. The basin has a cresent shape with longitudinal axis oreinting approximately in the northnortheast-southsouthwest direction, concexing towards the northwest. The maximum width is about 16 kilometres, and the length of the basin is about 50 kilometres (Figure 1.1.b).

The southern and central part of the basin are included in the administrative boundary of Amphoe Fang, whereas the northern part of the basin is in the administrative boundary of Amphoe Mae Ai of Changwat Chiang Mai.

1.2 Objectives of the Study

1.2.1 To study the geology of the Fang basin and adjacent areas with emphasis on the upper sedimentary sequence of the basin.

1.2.2 To reconstruct the geological evolution of the Fang sedimentary basin in the terms of sedimentation and tectonism.

1.2.3 To conduct the preliminary assessment study on the Tertiary sediments and the petroleum potential of the Fang basin.

1.3 Scope and Study Methodology

Basically the main goal of this study is to analyse the sedimentary facies of the intermontane basin.

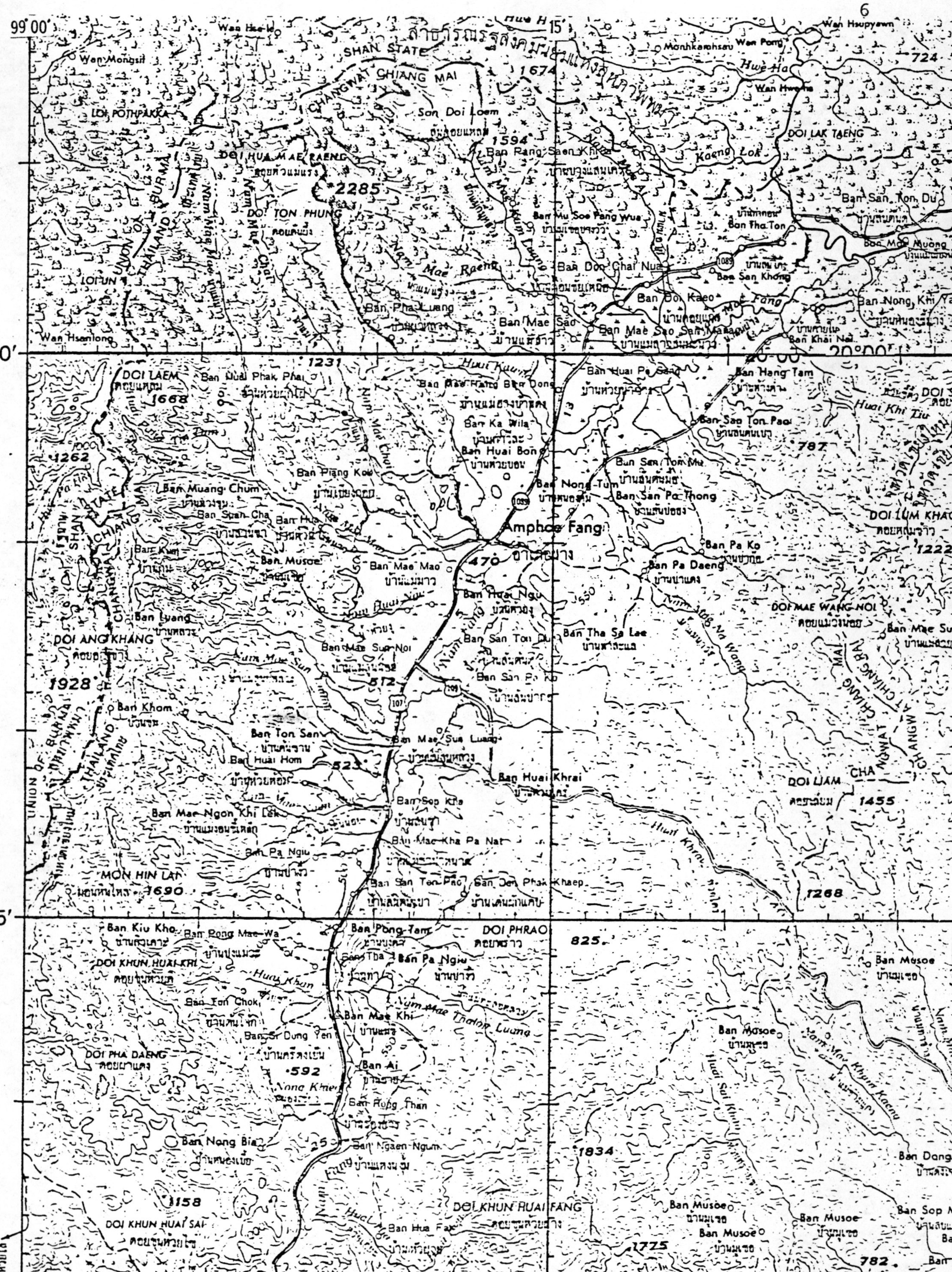

Figure 1.1.b Location map of the Fang basin.

In order to achieve this, fundamental concept, scope, and model of sedimentary facies have to be fully understood and defined to serve as the background of the study.

For the geologist working with ancient sedimentary rocks, a product of the depositional environment is a sedimentary facies. The term facies was introduced into geology by Nicholaus Steno in 1669, it meant the entire aspect of a part of the earth's surface during a certain interval of geological time (Teichert, 1958). The modern usage of the term facies which concerned the aspect of a rock was introduced by a Swiss geologist, Amand Gressly, in 1838. A major geological concept can trace back through the writings of Teichert(1958), and of Middleton(1973).

In sedimentology, Moore (1949) defined it as any really restricted part of a designated stratigraphic unit which exhibits characters significantly different from those other parts of the units. More precisely, Selley(1970) defined " a sedimentary facies is a mass of rock which can be defined and distinguished from other by its lithology, sedimentary structure, geometry, paleocurrent pattern, and fossils."

Fortunately, every depositional system cosists of numerous but limited depositional environments. Then the product of a depositional system comprises limited sedimentary facies which associated with each other. The relationships between these depositional environments in

space and hence stratigraphic sequences developed through time as a result of transgression, regression, and lateral accretion, was first found by Johannes Walther in 1894 which well known as Law of Correlation of Facies or Walther's Law. He stated that " the various deposition of the same facies area [depositional environment] and the sum of the rocks of different facies areas were formed beside each other in space, but in crustal [vertical] profile we see them lying on top of each other.....it is a basic statement of far-reaching significance that only those facies and facies areas can be superimposed primarily, that can be observed beside each other at the present time " (Middleton, 1973). Then the facies sequence can be defined as stratigraphic sequence if it represents a rational arangement of specific sedimentary facies of each specific depositional system. Details regarding this matter can be found in the writing of Walker(1983,1986).

The the final facies sequence of a specific depositional system elsewhere is only local summaries (a local model), not general model for a specific depositional system, when compare them with each other and data from modern one is incorporated, the points in common between all of these comparison begin to assume a generality that can be termed a model. Therefore, the facies model could be defined as a general summary arrangement of associated sedimentary facies of a specific depositional system.

The new approach to sedimentary facies analysis arises from the interrelationships of sedimentary environment and hence of facies are not chaotic or random, because they are subject to controls imposed by geological setting, tectonics, and climate. Thus, the distribution of facies is subjected to regularities, and the key to interpretation of sedimentary facies, therefore, is to combine observation made on their spatial relationships, and internal characteristics with comparative information obtained from facies model.

The value of such studies was clearly applied by Walther in 1894 who give them name "comparative lithology" or has been replaced by "facies analysis" in Russia (Blatt et al.,1980). Recognition of such a pattern in the vertical profile of this approach is also that of Visher(1965) as well as many nowadays geologists who engaged to analyse subsurface sedimentary facies.

Before going beyond to further step, some agreement should be made. This is, unfortunately, because the term facies has been used in many differnt ways. In this context, it has been used in interpretive or genetic mean. Another point which can not be overlooked is to define a scale of facies. In this context a fairly broad facies subdivision, facies sequence, is used depending on the available data. Unfortunately, it appears that the avialable data are not good enough to subdivide facies into sub-facies or facies of Selley (1970) in more detail.

Basically, the main methodology employed in the present investigation is so-called lithostratigraphic analysis of sedimentary basin or basin analysis. This method has been developed to assist the exploration of most of the geological resources derived from and associated with sedimentary rocks. Exploration of such resources required an understanding of their relationships to host strata, and the study of such host strata is known by convenient term as " basin analysis ". The work may include many components, amongst which the most important are stratigraphy, structure, and sedimentology (Conybeare, 1979; Jain & deFigueiredo,1982; Visher,1984; Miall,1984).

The basin analysis requires the application of many methods and techniques designed to elucidate various aspects of the geological history of sedimentary layers within the basins. These methods may be direct, as in the case of surface geological mapping and the examination of subsurface drill core and cutting, or indirect, as in the case of geophysical surveys and petrophysical logging of drill-holes. They are concerned with lithology, fossil and mineral content, grain characteristics, physical and chemical properties, and the geometry of stratigraphic bodies of rocks.

In order to fulfill the objectives and scope of the present study, six basic steps of approach have been proposed:

a) Review of the existing data and previous investigations.

b) Data acquisition, compilation and preliminary analysis.

c) Field observation, and acquisition of additional remained data.

d) Data analysis and interpretation.

e) Evaluation.

f) Conclusion, and reporting.

Primarily, the review of existing data and previous investigations including the regional geology of northern Thailand, and geology of the Fang basin are carried out to serve as a background of the study programme and to assist in identifying problems concerned. Special emphasis, however has been given to the geological setting of the Fang basin as well as adjacent areas, and existing subsurface data of the Fang oil field.

Within the 575-square kilometre area of the Fang basin, there are altogether seven petroleum exploration and /or production areas, namely, Chaiprakarn, Mae Soon, Pong Nok, Huai Bon, Pa Ngew, Pa Daeng, and Nong Khwang covering approximately 10, 4, 4, 5, 1, 5, and 1 square kilometres, respectively. With respect to the existing drill-holes data in these areas, there are 101 drill-holes

in Chaiprakarn area, 49 drill-holes in Mae Soon area, 12 drill-holes in Pong Nok area, 22 drill-holes in Huai Bon area, 12 drill-holes in Pa Ngew area, and 3 drill-holes in Pa Daeng area, and 1 drill-hole in Nong Khwang area (Figures 1.3.a, 1.3.b, 1.3.c, 1.3.d, 1.3.e, 1.3.f, 1.3.g, and 1.3.h). The total length of 201 petroleum exploration and/or production drill-holes in the Fang basin is approximately 105 kilometres. The drill-holes data and information include geological as well as geophysical logs. The geophysical log data available are mainly the self-potential, and resistivity with some gamma and neutron.

For geophysical survey data, there are magnetic anomaly, bouguer gravity, and seismic maps of the scale 1:50,000 which were prepared during 1961-1962 covering most part of the basin. In addition, the vertical gradient and tentative structural maps were subsequencely prepared using the original bouguer gravity and seismic maps, respectively. Last, there are seismic map and profiles of the seismic survey conducted in 1986 covering some parts of Mae Soon and Pong Nok areas of totally 180 square kilometres available.

In addition to the existing data and information on drilling exploration and/or production, subsurface geology and geophysics, there are some information on the petrophysical properties of reservoir rocks, characteristics of crudes, petroleum reservoir geology,

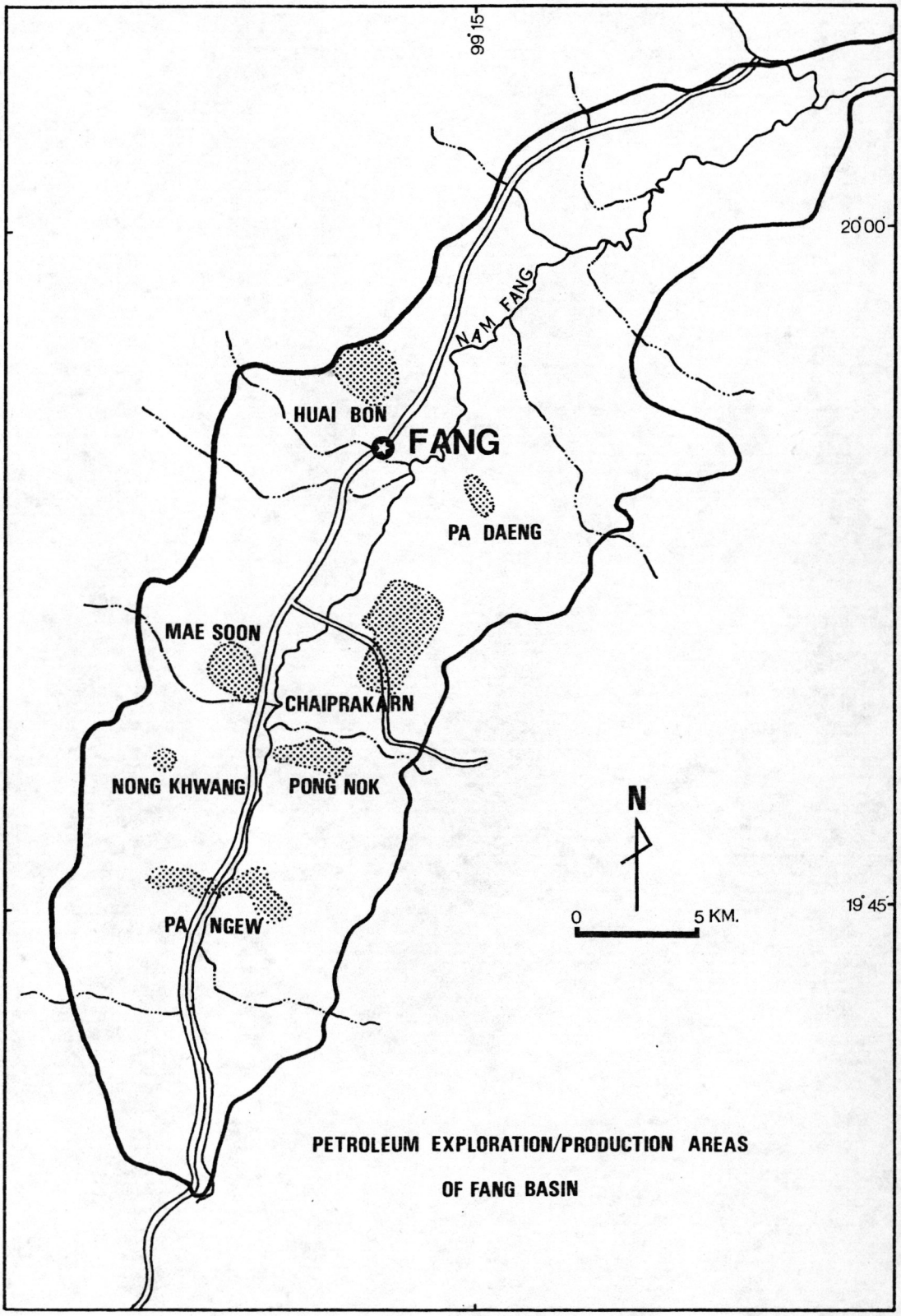

Figure 1.3.a Map showing the petroleum exploration/production areas of the Fang basin.

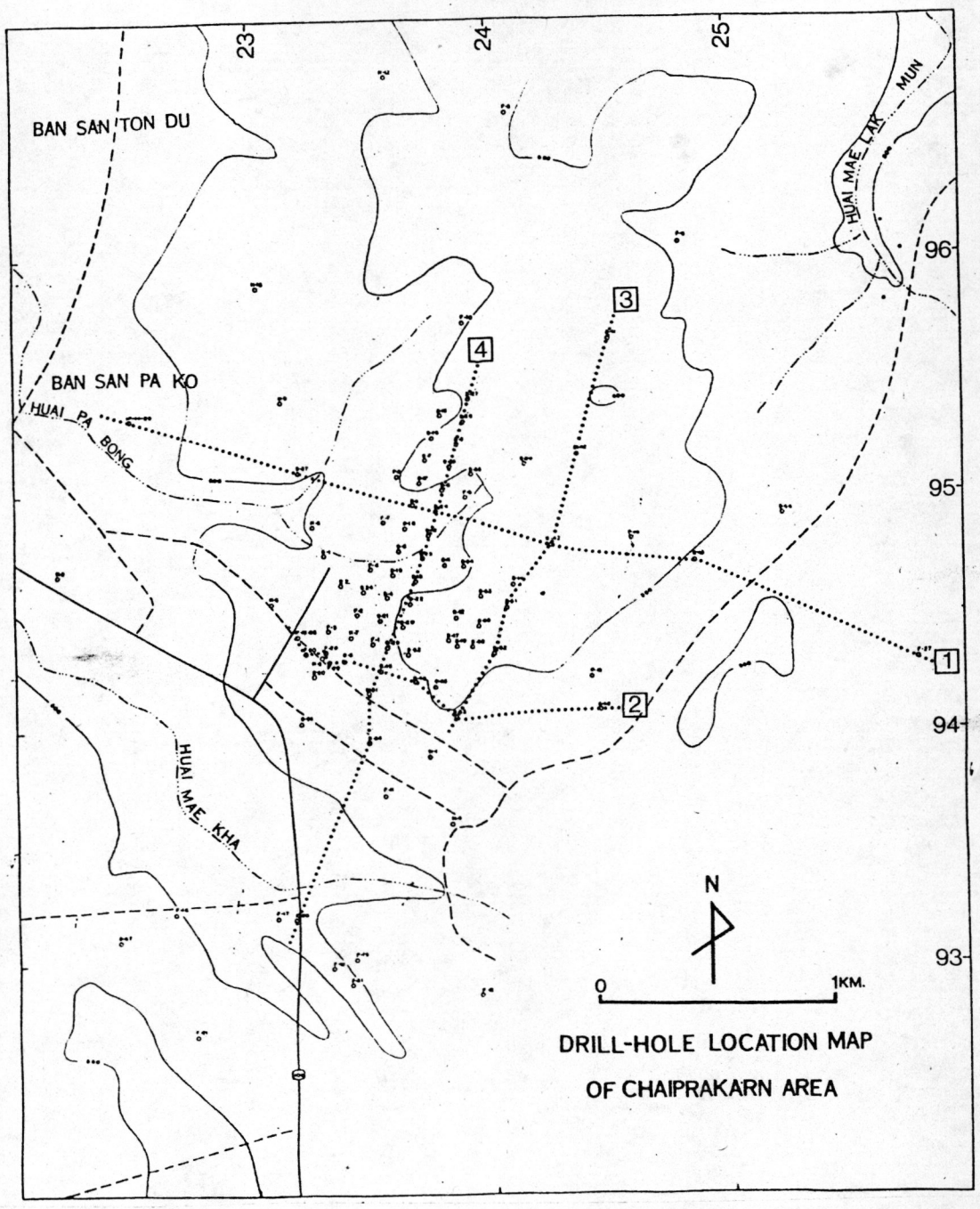

Figure 1.3.b Drill-hole location map of Chaiprakarn area with lines of facies profile.

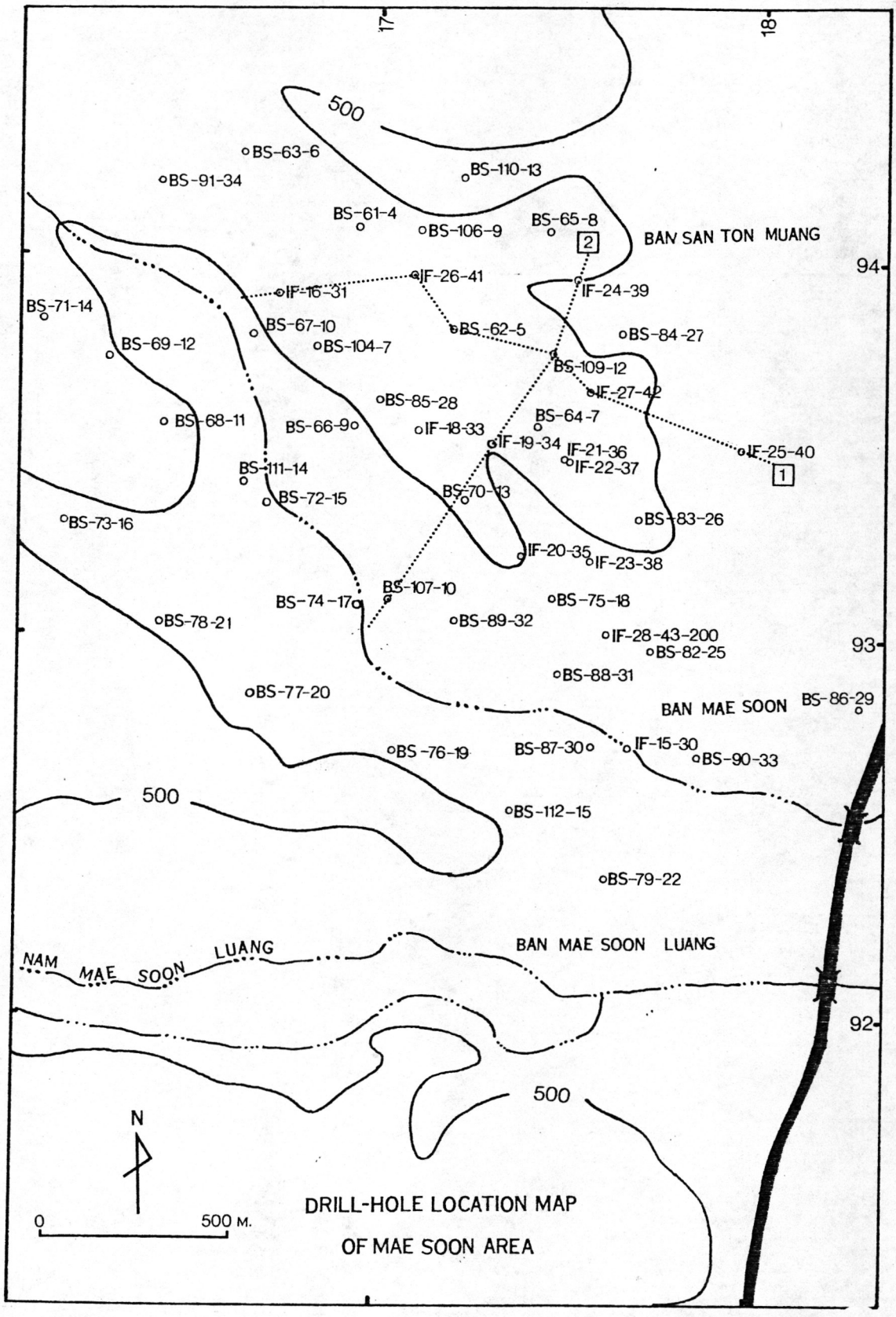

Figure 1.3.c Drill-hole location map of Mae Soon area with lines of facies profile.

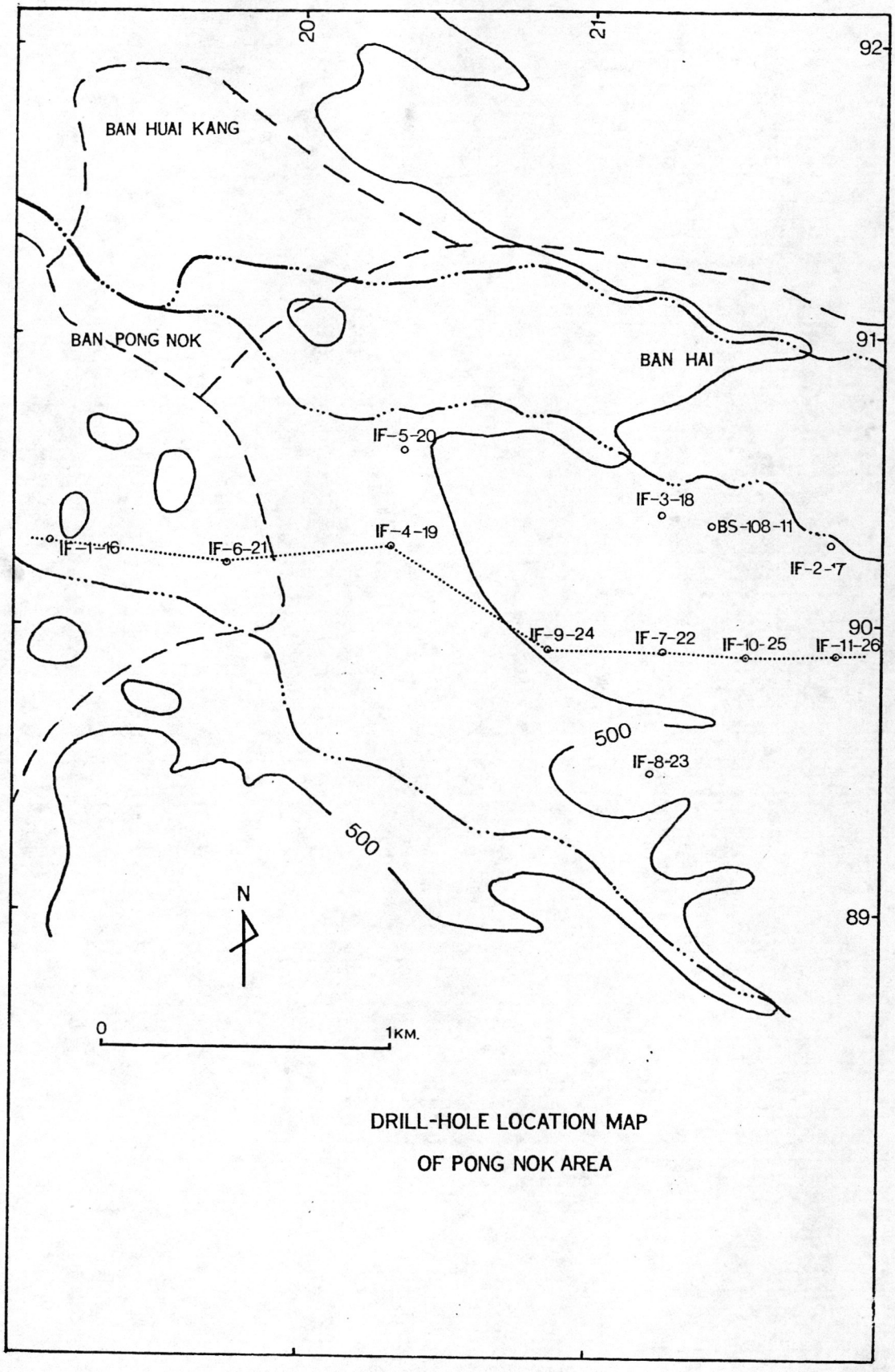

Figure 1.3.d Drill-hole location map of Pong Nok area with line of facies profile.

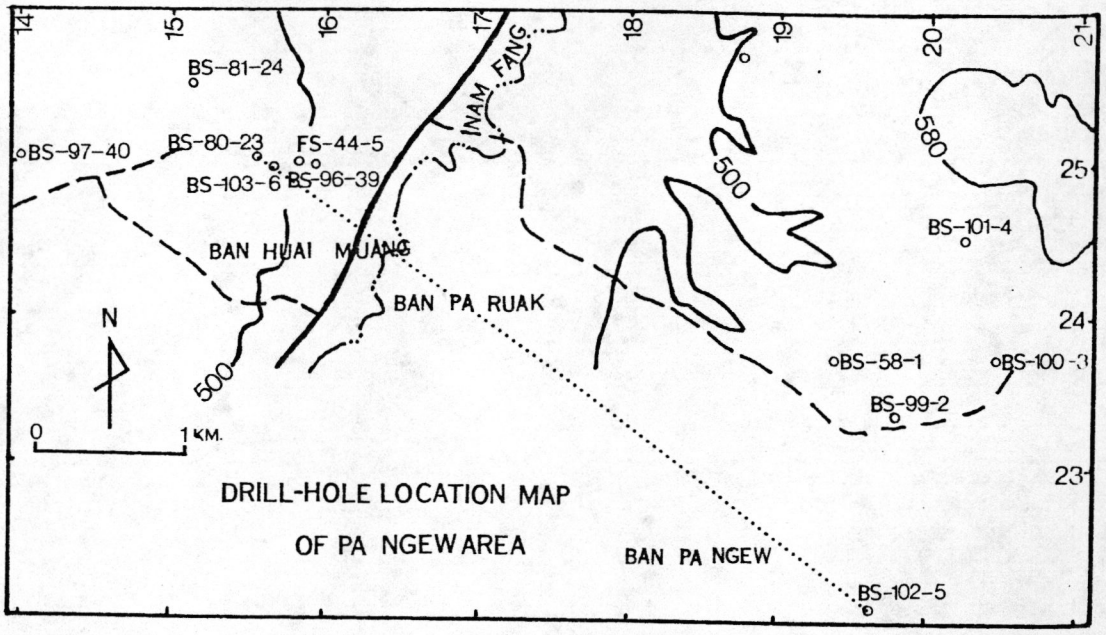

Figure 1.3.e Drill-hole location map of Pa Ngew area with line of facies profile.

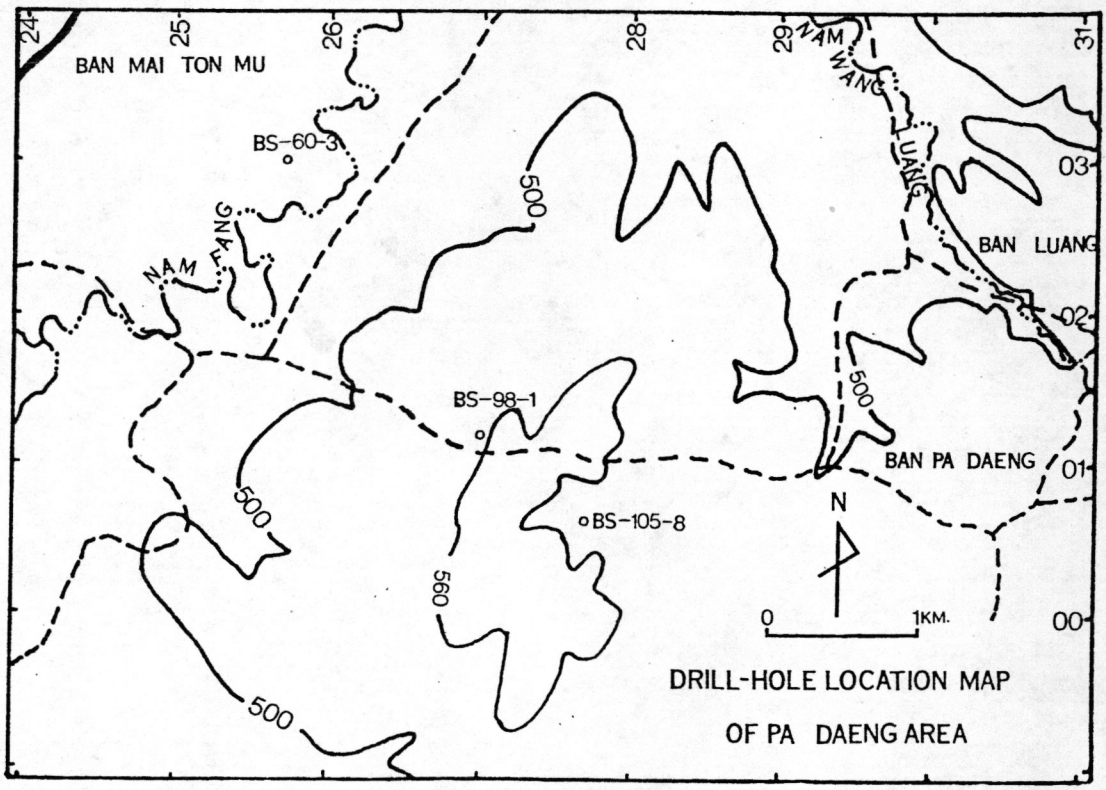

Figure 1.3.f Drill-hole location map of Pa Daeng area.

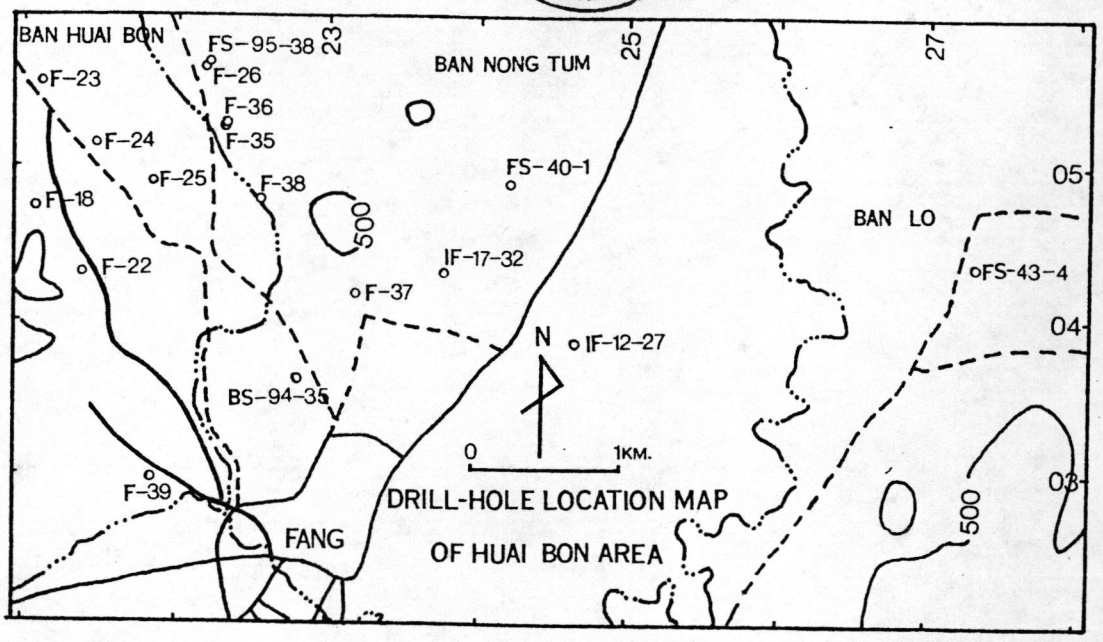

Figure 1.3.g Drill-hole location map of Huai Bon area.

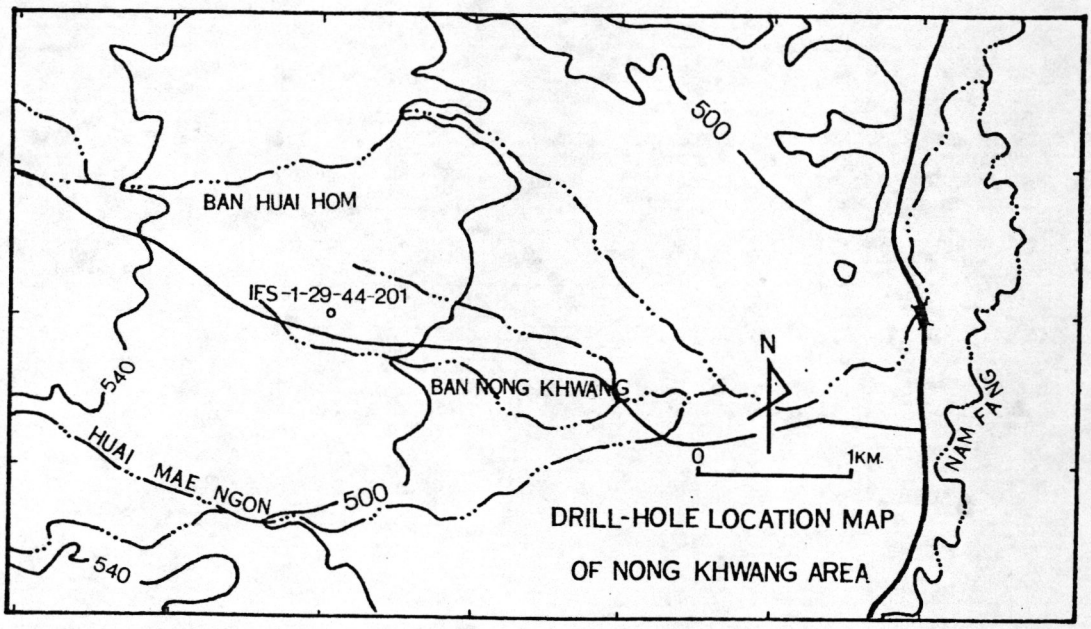

Figure 1.3.h Drill-hole location map of Nong Khwang area.

and production statistics of the Fang oil field avialable.

It is against the compilation and analysis of previous outlined data ,the present study programme has been accordingly designed and formulated. The scope of the study includes the following aspects, notably, the configuration of Cenozoic Fang basin, the analysis of subsurface facies of the Upper Tertiary and Quaternary deposits, lithostratigraphy and structure of the basin-filled sediments, geological evolution of the basin, and petroleum potential of the basin.

During the study programme, the field trips were conducted aiming at the acquisition of addtional required data and observing the geology of the area as well as the petroleum exploration and production activities.

The final steps of work cover the data analysis and interpretation, evaluation as well as reporting, respectively. The approach and techniques employed in the present study are summarized and presented in Figure 1.3.i.

1.4 Previous Investigations

Historically, one episode during the Thon Buri period it had been recorded that a pause during the war between Thailand and Burma, the Thai commander, Chao Phraya Chakri, gave a pot of crude oil as a token to the Burmease commander, Asaewunkee. It is confidently regraded that the crude oil was obtained from Fang because

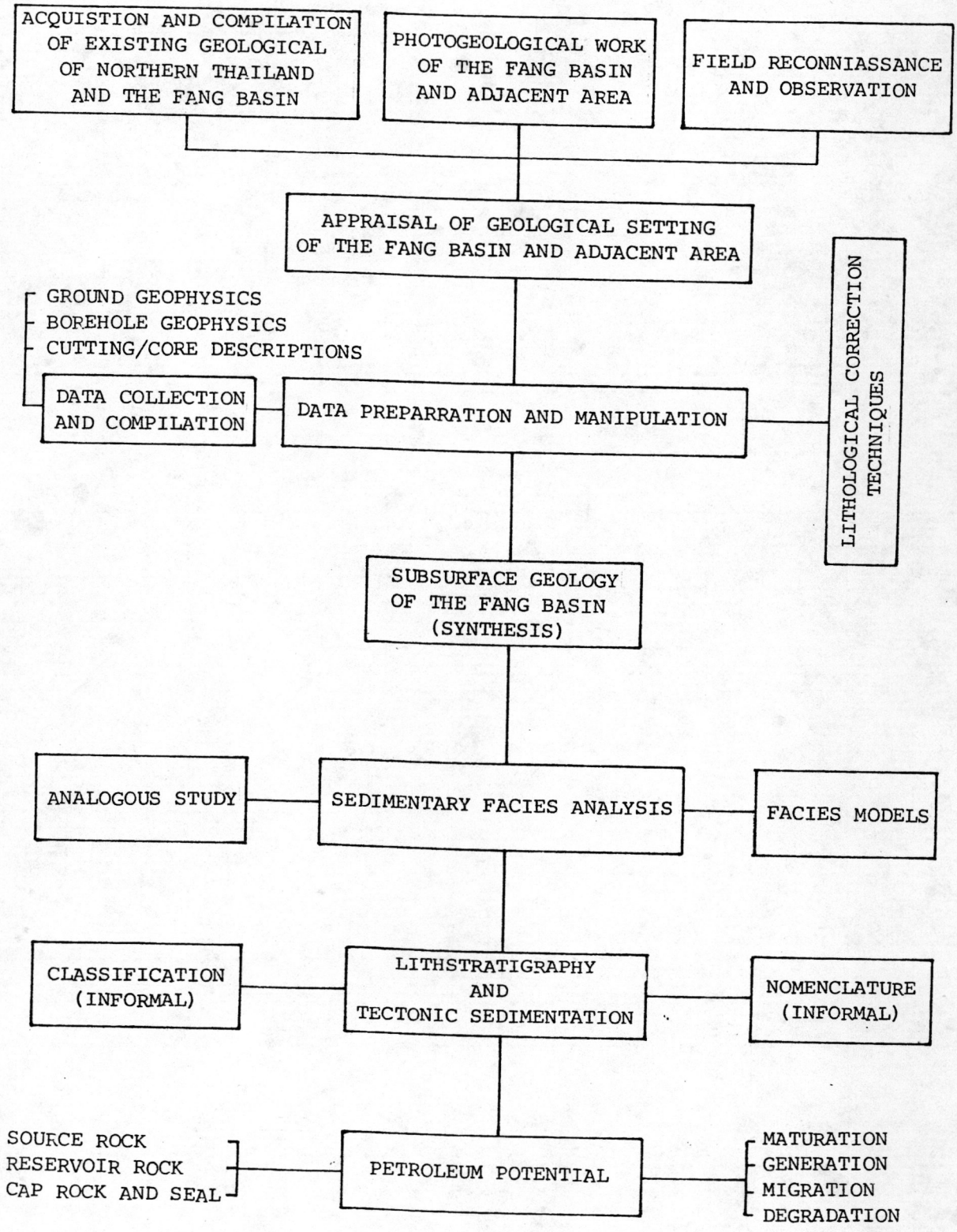

Figure 1.3.i Flow-chart illustrating the methodology and steps of work in the analysis of the Fang basin.

at that time and latter, no oil had been found in other places in Thailand.

About one hundred years ago the King of Chiang Mai, Chao Luang Chiang Mai, knew that oil had been found at Fang in the form of oil seeps. The people in the vicinity of Fang used it to cure all kinds of skin disease. Chao Luang commanded his officials to dig a shallow pit so as to contain the seeping oil, called " Boh Luang Well ".

During the early establishment of Royal State Railway of Siam in the reign of King Rama V, The Great, the governor of the Royal State Railway of Siam at that time, Prince Kamphangbej who is the King's younger brother, had been informed about the oil seep at Fang. In order to acquire fuels for the railway's steam locomotive, in 1921 he had employed an American petroleum geologist, wallace Lee, to explore the mineral fuels, petroleum is one kind, in the Thailand. As a consequence, the Fang petroleum geology had been first studied at that time. At the same time the Royal State Railway of Siam had also bought a drilling equipment, and had employed a Italian engineer to operate the drilling equipment. The first two holes were drilled close to the Boh Luang well, of about 216.30 and 180.15 metres depth. The holes were not successful on account of broken casing. The subsequent drilling programme had stopped.

After a six-month exploration, during December 1921 and May 1922, Wallace Lee had submitted his report " The Reconnaissance Geological Report of the Districts of Payap and Maharashtra, Northern Thailand " to the Royal State Railway of Siam in 1923. The Fang petroleum geology was first briefly described in this published report as well as geological sketch of the Fang basin as shown in Figure 1.4.a. According to Lee (1923) from his a short-time study and data obtained in the field, it was insufficient to determine conclusively the structure underlying the basin. He attempted to interpret the structure, that the beds resting unconformably on the granite on the eastern side. By this hypothesis, the strata overlying the granite on the east were supposed to be equivalent, in the part of lithology similar to beds in the mountain range west of the basin. A sketch explanation of his hypohesis is shown as interpretation No.1 (Lee, 1923) in Figure 1.4.b. Another hypothesis is also possible, the beds on the eastern margin of the basin are certainly younger than the granite. Although no fossils were found and no direct evidence was secured, it has become increasingly possible that the beds on the western margin are Paleozoic, older than the granite, and not equivalent to the beds resting on the granite. He believed that the Fang basin is not a simple erosional basin as firstly supposed, but like the other owes its existence to subsidence of portions of the strata accompanied by faulting and intermittent or progressive

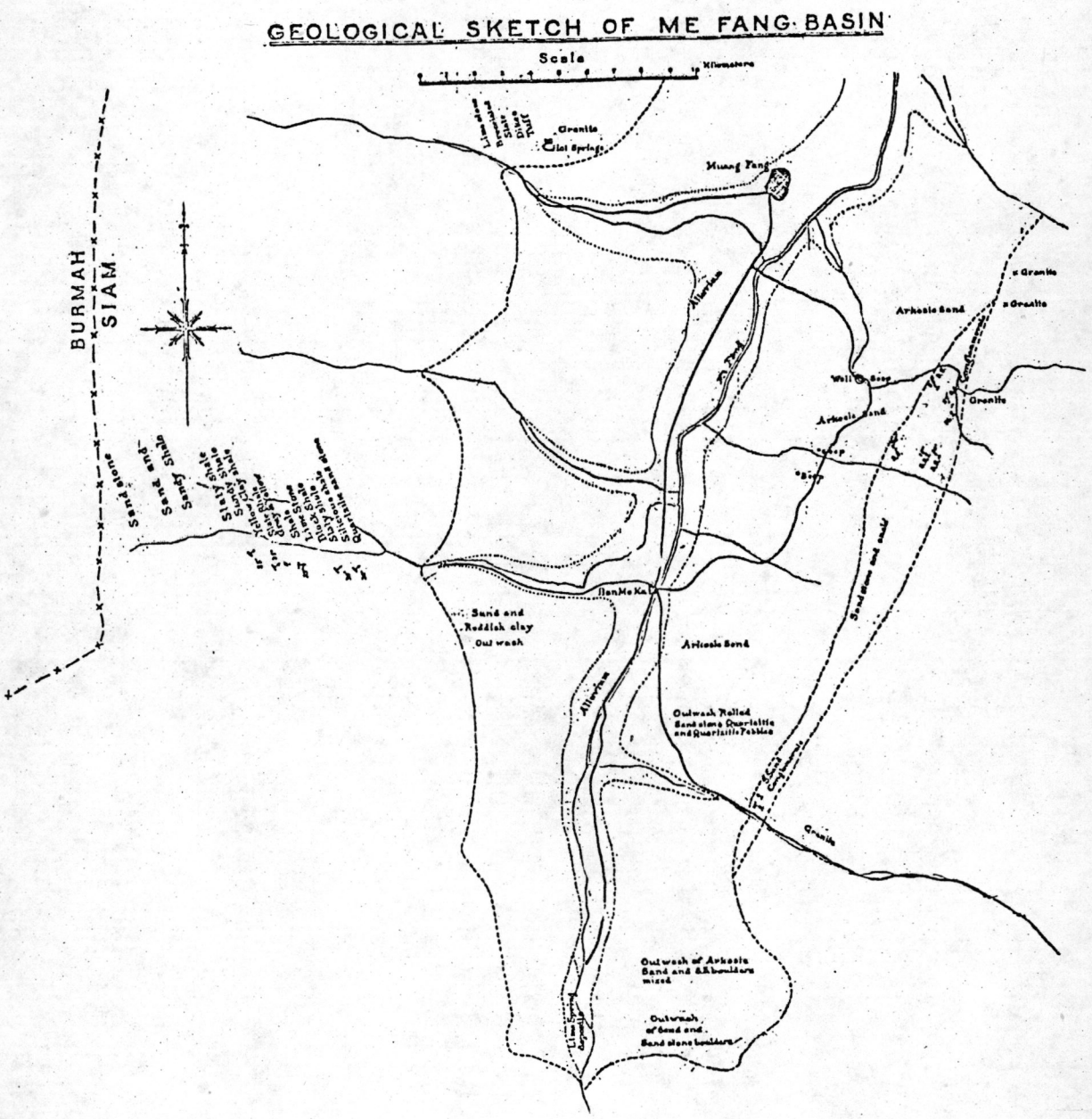

Figure 1.4.a The geological map of the Fang basin. (Lee, 1923)

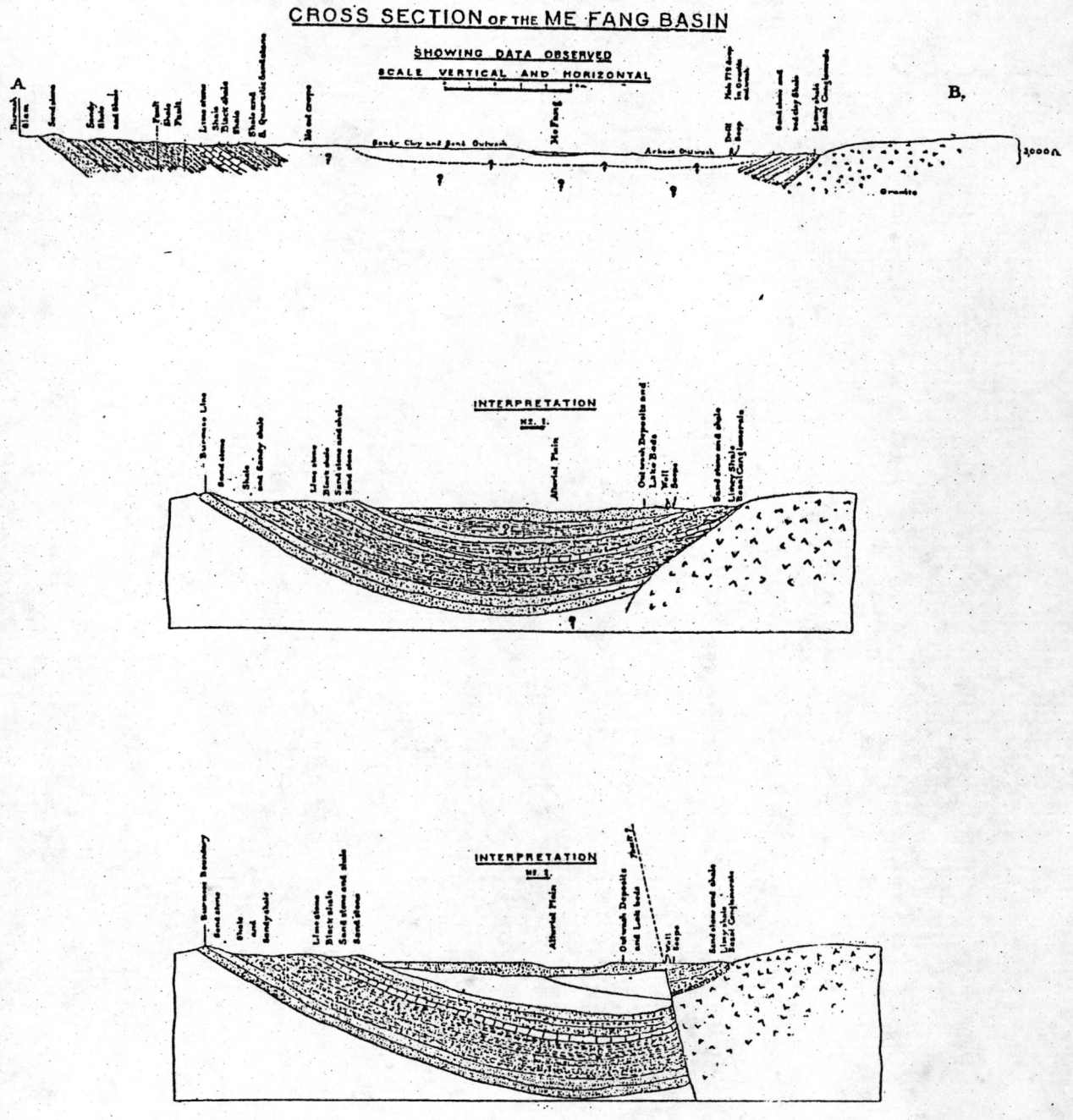

Figure 1.4.b The geological cross-section of the Fang basin. (Lee, 1923)

folding of the deposits. The latter alternative hypothesis is represented in sketch No.2 (Lee, 1923) as shown in Figure 1.4.b. The origin of the petroleum is briefly written in that report but more detail is given in the following writing of Lee(1927).

Lee(1927) described that the three tar seeps in the narrow Mae Fang Valley [Fang basin] occurred on the eastern margin of the synclinal basin between Paleozoic metamorphic rocks on the west and Triassic red sandstones and granite on the east. One of these seeps, tar escapes through outwash alluvium in the bed of small stream, tributary of the Mae Fang river. But source of the oil is problematical and no Tertiary beds are known to be present in the country including the Fang area. Triassic and Paleozoic rocks surrounding the basin seemed to be equally unsuited as the source bed. So one of his hypotheses was that the basin itself represents one of the Pleistocene deposits and that intrusions of igneous rock, at several places in the valley where there are hot springs, might come into contact with lignite [coal] beds so frequently found in the Pleistocene basin deposits, thus resulting in the distillation of tar.

After a eleven-year pause of the petroleum exploration in the Fang basin, in 1934 or 1935(?) the Fang project under the authority of the Royal State Railway of Siam had been transferred to the Army Fuel Department. Two Swiss geological experts, Dr. Arnol Heim and Dr. Hans

Hirschi had been engaged to explore petroleum in the Fang basin together with two Thai officials Pra Udom Pithayaphumichan and Nai Sae V. Pienpitaya. They had attempted to investigate how oil seeping through the sediments. They scrutinized the ground-surface geology and some shallow pits. This investigation lasted for more than one month before it had paused again. The report was available at the Department of the Mineral Resources, Ministry of Industry (Buravas, unpublished data).

In 1938[?], Army Fuel Department had employed the Japanese geologist, Y. Naita, to conduct additional investigation on the petroleum geology of the Fang basin. His report was not satisfactory (Sethakul et al.,1984).

In 1936, the Fang project was under authority of the Highways Department. The aim of the Highway Department was that to search for the raw materials, tarsand, near the ground surface to be used as route-building material. The project had paused again, because the petroleum affairs was considered to be improper function and responsibility of the Highways Department.

From 1949 through 1956 , the Fang project was under the authority of the Department of Mines (presently known as Department of the Mineral Resources). It was recorded that the first geophysical survey in the Fang basin, Chaiprakarn area, had been conducted using the seismic survey technique in 1951.

Brown, Buravas, Charaljavanaphet, Jalichandra, Johnston, Sresthaputra & Taylor(1951) supported Lee's hypothesis on the origin of oil in the basin. Brown, Jalichandra & Taylor had also compiled the Geological Map of the Fang basin and surrounding areas in the 1:100,000 scale after that of Lee in 1923 (Figure 1.4.c).

In March, 1956 the petroleum expert, Dr. Harold Hutton, went to Fang. He recommended that the Fang oil could be distrilled for sale and should be further explored and investigated.

On September 12 of 1956, the Thai Government had made the decision to transferred the authority over the Fang project from the Department of Mines to the Department of Defence Energy, Defence Ministry.

In 1956, the Department of Defence Energy had employed R. Frank and E.D.Sherman, petroleum engineer and petroleum geologist, respectively, to investigate the Fang oil field. After about one month, during November and December, of data collection they presented " The Report on Engineering and Geological Survey of Mae Fang Valley, Thailand," on December 12, 1956 (Frank & Sherman, 1956, unpublished data).

Sherman(1956, unpublished data) also wrote that the Mae Sot Series at that time thought to be late Tertiary in age is represented by fluviatile, lacustrine, deltaic(?), and lagoonal(?) deposits. The age

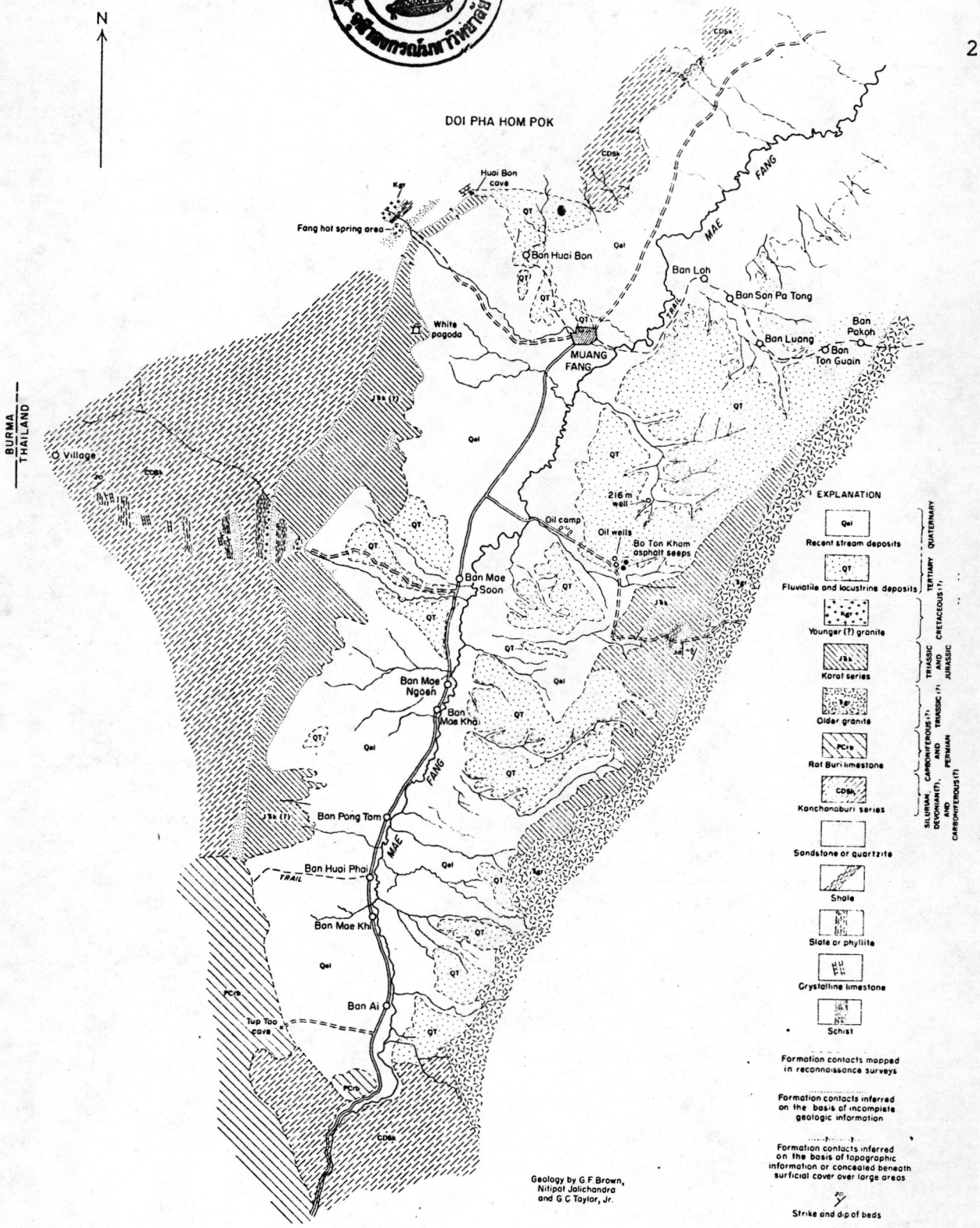

Figure 1.4.c The geologacal map of the Fang basin. (Brown et al., 1951)

determination is based on fresh-water gastropods, and fossil fragments of vertebates collected by Wallace Lee in the drilling of the drill-holes close to the Boh Luang Well in 1921-1922. The Fang basin is structurally a double plunging syncline, or at least a modified syncline. The Fang oil field [Chaiprakarn oil pool] is a structural trap reservoir and may be classified as a faulted monocline. After preceeding study, he proposed other prospective areas. They are Area 1: Ban Pakoh, Area 2: Ban Huai Bon, Area 3: Ban Mae Khi, and Area 4: Ban Mae Soon.

Around the year 1958, T.Brooks, the geologist who was employed to investigate the Fang oil field, attempted to study the Chaiprakarn oil pool. He drafted the structural contour map on the upper surface of Chaiprakarn Sand, in the 1:5,000 scale on September 26, 1958.

Samathapand (1959) suggested that the oil may have been derived from organic matter provided by plant remains and brackish water molluscs commonly found in the lower part of the sequence (Chaiprakarn oil pool) in the basin itself.

In 1961, Geophysical Service International Ltd. (GSI) had been engaged to explore almost all of the Fang basin by geophysical methods based on magnetic and gravimetric principles. As a result, magnetic anomaly map, and bouguer gravity map both in the 1:50,000 scale are obtained. The magnetic anomaly map does not show strong

anomaly, except in the southern and far northeastern parts, which indicate that igneous intrusions are not too numerous, except in those parts. The bouguer gravity map shows three negative anomalies which lie elongated in the northnortheast-southsouthwest. These zones can be interpreted as three sedimentary sub-basins. On the flanks with steep gravity gradients can be interpreted as fault-bound or garben type basin. The bouguer gravity map shows at least five positive anomalies which may be interpreted as anticlines and/or basement high areas.

In 1962, Compania General Di Geofisica (CGG) had been engaged to explore a part of the Fang basin, after preceding magnetic and gravity surveys, using the seismic reflection method. The conclusion of this exploration is that the Fang basin consists of three basement troughs, stretching northnortheast-southsouthwest, with asymmetical flanks. The eastern one is of regular slope, whereas the western one is often of sheared dips and faults. On the eastern flank, there are movements of less individualized but more regular and greater extension. The shape of Jurassic and Tertiary horizons differ from that of the basement, and separated from one another as a consequence of the unconformity. It seems that the central sub-basin was deepened during Tertiary. No simple structure of anticlinal type appears, even in zones of saddles between sub-basins. Oil traps must be of stratigraphic types, or of wedges, truncated by faults. As a consequence of large

areal extent of Tertiary sequence, their gentle sloping characteristics, and of less fault, the eastern margin of the basin seems to be more favourable for oil search than the western one. But, however, the individual structural zones at Ban Mae Soon area and Ban Huai Bon area have to be tested. As a consequence of its possible deepening of the central sub-basin during Tertiary, and the anomalies at the marginal zones of the basin, the marginal areas seem to be more favourable.

Sundharowat (1964) conducted the literature research on the origin and genesis of kerogen and petroleum. He concluded that the Mae Fang oil at Chaiprakarn area had originated from humic substances supplied from the land surrounding the Mae Fang basin in the Tertiary Period. He thought that the highly asphaltic nature of the Mae Fang crude oil substantiated its young origin and precludes any possibility of previous long-distance migration. He also felt that the surprizingly low sulphur content of the crude suggested a non-marine environtment for the Tertiary Mae Fang basin.

Miss Varunee Bunyannanonda (1968, unpublished) had been asked to analyse for pollen and spore by Samark Buravas, Chief of Geology Section of the Department of Defence Energy. She found some kinds of pollen and spore, namely, Microhenrici , Henrici, Salix, Pollenites fallax, and Pinus hapoxylon. According to these pollen and spore, Oligocene Epoch had been assigned to the sediments which

contained these fossils, and to that Fang basin.

Hashimoto, Buravas & Kudo(1968) suggested that the Mae Fang crude may have originated from the Kanchanaburi Series with intercalations of graptolite shale bed, or from older, perhaps Paleozoic formation. Because there is seemingly no rocks facies suitable as source rock, while a small amount of coal and carbonaceous shale can be recognized in the basin; compared with Japanese crude oils, the Mae Fang crude is extraordinary rich in "aromaticity" which seems to increase as the geological age becomes older; by comparison the graptolite shale of Silurian is rather similar to the crude.

Buravas(1970) wrote that the Fang is exclusively a structural basin bounded by step faults, called graben, and the basin seemed to have been formed at the close[?] of the Cretaceous Period when the Pa Hom Pok range of granite gneiss of Fang was elevated higher and higher, while the basin of Fang sank down lower and lower as a basin. He attempted to subdivided the stratigraphy that will be presented in heading 2.4.2 named Tertiary Stratigraphy in the next chapter. In 1963, Mae Soon oil pool had been discovered. As a consequence, two types of oil in Fang, namely, asphlatic base crude, and paraffinic base crude, in Chaiprakatn oil pool and Mae Soon oil pool, respectively have been reported.

From 1966 through 1968, Professor W. Gaines of the Chiang Mai University Chemistry Department wrote that the thick viscous oil of Chaiprakarn and the Mae Soon crude oil had been derived from the coal beds of Fang through metamorphism of the coal (Buravas,1970).

From 1965 to 1971 the northern geology of Thailand had been investigated by German Geological Mission, GGM (1972). They had compiled geological maps of the northern region of Thailand including the Fang basin and surrounding areas in the 1:1,000,000 scale. Braum & Hahn(1976), members of GGM, had also compiled "Geological Map of the Northern Thailand" sheet No.2 "Chiang Rai" including the Fang basin and adjacent areas in the 1:250,000 scale.

In 1973, Samark Buravas had studied the succession of rocks in Fang and Chiang Mai areas which will be presented in the heading 2.4.2. And in 1974, Samark Buravas had sent many samples of coal of the Fang basin to be analysed for the proximate analysis. In the writing of Buravas(1975), he had compared the proximate analysis of the coal of the Fang basin to that of other basins of Thailand as well as some fossils. As a cosequence, the Miocene-Pliocene Epoch had been assigned to the Fang basin deposits. It is also noted that the results of palynology which analyzed by Miss Varunee Buyannanoda from Department of Geology, Chulalongkorn University, and by Dr. P.R. Evans from Department of Mineral Resource, Canberra,

Australia, were that the Tertiary deposits should belong to the Oligocene-Miocene. Besides, some spores and pollens also belong to the elevated area with fairly cool climate.

From April 30, through May, 1976, two Rumanian experts had come to Thailand, and also to Fang so as to plan for the next collaboration for petroleum exploration in the Northern Thailand.

1979 Piyasin wrote that the orogeny of the northern region of Thailand resulted from the epirogenesis and fault movement. The Fang basin was formed during and/or after this process with major fault on the west rim of the basin from middle to late Cretaceous Period through Tertiary Period. The western mountains had uplifted whereas the basin had sank down at the same time. He subdivided the sediment deposits into two formations, namely, the Mae Fang Formation and Mae Sot Formation. There is basal conglomerate comprising of intraformational claystone and /or shale phenoclasts of the Mae Sot claystone and/or shale lie unconformably under the Mae Fang Formation. He also suggested that the petroleum of the Fang basin had been generated from plant and animal remains which deposited in the Mae Sot Formation. Naphthelene [Asphaltic] base crude might be generated from the mixture of coal and animal remains (mollusc and insect), whereas the paraffinic base crude might be generated from coal seams which interbedded with bituminous [coaly] shale and siltstone (Piyasin, 1979).

In 1979, Kanchana Kaewkumnert wrote " A predictive study and chemical analysis of tar sand deposit at Fang, Chiang Mai," which mostly concerns with the quality of tar sand of the Chaiprakarn area in both chemical and physical aspects (Kaewkumnert, 1979).

From September 25, through October 10, 1980 two Rumanian geologists , Dutescu Pompilian and Enache Vasile, expertise in exploration and exploitation had been engaged to investigate the Fang basin. In the unpublished report (Dutescu & Enache, 1980) the Tertiary Fang basin is the intracratonic type basin. It was formed during intra-Miocene orogeny as a result of epirogenic movement that responsible for the formation of a graben-type structure on the central zone of Shan Thai Craton (on the marginal platform of Alpine geosyncline system). The whole sedimentary sequences have to be regarded as constituting a Mio-Pliocene sedimentary cycle made up of lacustrine facies which was overlain by the fluviatile and continental deposits [Pleistocene ?]. Of the three sub-basins, the central one is most important considering from the hydrocarbons generating and volume of the Tertiary sediment points of view. The oil source rocks are shale of the Mae Sot Formation. The presence of the bituminous and carbonaceous rocks are possible a coincidence and this should explain the fact that, at the same time, the abundance of fauna and flora was the possible origin of the oil. All of the oil pools in the Fang basin are

connected with [? have relationship with] the buried relief(high) and oil accumulations are a result of lateral migration up dip of the basement high areas.

Enache (1981, unpublished report) had emphasized the investigation in the Pong Nok oil pool. He had investigated the IF-11-26 Well which was drilled according to the suggestion of Dutescu & Enache(1980) and had discussed many aspects of the Pong Nok oil pool. Finally, he gave some recommendations on the exploitation.

Dutescu (1981, unpublished report) had emphasized the investigation in the Huai Bon area. He had investigated the IF-12-27 Well which was drilled according to the suggestion of Dutescu & Enache(1980). He attempted to correlate the results of that well with the Pong Nok, the Mae Soon, and the Chaiprakarn oil pools. He divided the sedimentary sequence of that well into two formations, first, the Mae Sot Formation which comprises three members, namely, the Lower Shale Member, the Middle Red Clay Member, and the Upper Clay Member in ascending order; second, the Mae Fang Formation. He also gave many recommendations. Finally, he wrote that drilling withuot proper geological and geophysical investigations of the the bore-hole data will not solve the problem.

Sethakul, Kruepang & Amphipugdi(1984) attempted to investigate the Pong Nok oil pool based on the available data at that time. They had subdivided the sedimentary

sequences into two formations, namely, the Mae Sot Formation which composed of the Lower Mae Sot (Chaiprakarn Sand), the Middle Mae Sot, and the Upper Mae Sot Members based on the lithology; and the Mae Fang Formation.They attempted to measure the geothermal gradient based on the drilling mud temperature which is about 1.1° -2.0° F/100 feet. Therefore, at the deepest part of the Pong Nok area of 4950 feet., the temperature should be approximately equal to 159.25° F. For this temperture, it must have taken about 150 million years to generate petroleum from available organic matter of suitable quality and quantity. Therefore, it is not possible that petroleum had been generated in the Pong Nok oil pool in situ. The oil must have been generated from other places. They believed that the oil had migrated from the buried places in the western part near the Mae Soon oil pool. This is because the Mae Soon oil pool contains not only paraffinic crude oil similar to the lower oil zone of the Pong Nok oil pool but also gases; and the groundwater recharge on the western margin is much higher than that of the eastwen margin; and the structure of the Pong Nok oil pool is monocline dipping to the west. So oil should migrate from the buried places on the west near Mae Soon to the Pong Nok oil pool on the east. The water in the oil field was also analysed for some ions. The results reveal that Ca, Mg, are much more higher than Na, Cl which indicate that although the Fang basin is the continental origin, the water quality indicates marine characteristics. The environment of

marine basin may be present in the Lower Mae Sot Member and changing to true freshwater in the Middle Mae Sot Member as indicated by coal fragments and remains of Viviparous available.

In 1984, Professor Dr. M. Streel of the Leign University, Belgium, had analysed rock samples from the Fang basin for spore and pollen. The four samples were collected from IF-15-30 and IF-22-37 wells of the Mae Soon oil pool, detailed information is discussed in the writing of Ratanasthien (1984). Senonian or Paleogene age [Epoch] is assigned for these samples, which should be correspond to nearshore-deltaic facies with marine incursions (Ratanasthein, 1984).

In 1985, Sethakul attempted to investigate the Mae Soon and the Pong Nok oil pools. The writing about the Pong Nok oil pool is not different from the preceeding writing (Sethakul et al.,1984). The Mae Sot Formation represents fluvio-lacustrine facies and/or possibly nearshore-deltaic facies with marine incursion on account of his previous chemical analysis of oil field water and writing of Ratanasthien(1984). He also wrote that the lower sequence of the Mae Fang Formation representing the fluvio-lacustrine sequence of small and shallow basin with oxidizing facies, whereas the upper sequence representing energetic alluvial and fluvial facies in the tropical zone. He assigned the structure of the Mae Soon oil pool as an asymmetrical anticline resulting from the compaction

on the pre-Tertiary basement. He also attempted to described the distribution of two important pay zones, namely, Pang Sak Sand and Ang Khang Sand. Besides, the physical properties and the fluid content of marjor oil zones are discussed. Finally, he proposed additional opportunity for oil discovery in the areas which need further drilling to reconfirm the finding .