CHAPTER IV

GEOLOGY OF THE UPPER GULF OF THAILAND

The stratigraphy of the Upper Gulf of Thailand is poorly established because the lack of data. However, in this study the sedimentary data of the Hua Hin basin and the adjacent basement-high areas are available for facies analysis and reconstruction of depositional environment. These sedimentary facies are used in the correlation and formulation of the proposed lithostratigraphy of the Upper Gulf of Thailand.

4.1 The Sedimentary Facies on the Basement-High Areas of the Upper Gulf.

As a matter of fact, the Hua Hin basin can be subdivided into 3 depositional sequences,from seismic section and geophysical logs, by the three markers which are used to correlate the depositional sequences through the Hua Hin basin and the Upper Gulf of Thailand. Generally, the three markers are usually present in the grabens, half-grabens in the Upper Gulf but in the horst or basement-high area intervening these small basins the middle marker is absent because there was no deposition of the lowest sedimentary sequence in these areas (Fig.3 c). Therefore, the Hua Hin basin can be subdivided into 4 sedimentary facies according to intergrate the lithological and geophysical characteristics of information from Phetchaburi-1 well as summarized in Figure 4.1. a

The lithological characteristics of Tertiary sedimentary sequences on the basement-high areas of the Upper Gulf are revealed

DEPTH (ft.)	Sedimentary Facies	DESCRIPTION	PALEONTOLOGY	AGE	ENVIRONMENT
	D	Uncompacted thick brown, yellow clay separated by thin quartz sand beds	—	PLIOCENE TO HOLOCENE	Shallow marine
		LATE PLIOCENE UNCONFORMITY ?			
2000	C	Thick bedded sandstone separated by brown, yellow clay ss / cl = 1:1	—	LATE MIOCENE TO PLIOCENE	Fluvial dominated meandering stream
		LATE MIOCENE UNCONFORMITY			
4000	B	Series of fining upward sequence from sandstone or siltstone to shale intervening with the thick sequence of association of shale, calcareous shale, limestone	3680´ gramina, quercus, alnus, florschuetzia - levipoli Age : Miocene	EARLY TO LATE MIOCENE	Fluvio-lacustrine
6000					
8000		Reddish brown to grey shale interbedded with light grey, white, brown, red limestone, trace of coal and siltstone			
		EARLY MIOCENE UNCONFORMITY			
10000	A	Red, brown to dark grey shale, calcareous shale interbedded with white, grey, green, red limestone and trace sandstone sh / lst = 1:2	9420–10830´ stenochaena - laurifolia florschuetzia - levipoli/semilobata Age : Miocene	OLIGOCENE TO EARLY MIOCENE	Lacustrine
12000					
14000			9360–10989´ classopollis sp. circulina parvar Age : Cretaceous Rework fossils ?		
16000					
18000		UNCONFORMITY ON PRE-TERTIARY BASEMENT			
20000		—	—		—

Figure 4.1 a Summarized characteristics of the sedimentary facies in the Hua Hin basin.

by the three wells which were located in the Upper, Middle and lower parts of the Upper Gulf. Krabang-1 well was located in the north-eastern basement-high area of the Upper gulf at latitude 12°59' 50" N and longitude 100°24' 07" E with total depth of 3,622 feet. Nong Kae-1 well was situated at the central basement-high area at latitude 12° 32' 49" N and longtitude 100°18' 15" E with the total depth 4,211 feet. The Sattakut-1 well was situated at the southern basement-high area at latitude 12°08' 56" N and longtitude 100°27' 39" E with total depth 4,353 feet (Fig. 3.2.2).

From the integration of geological data, geophysical logs and ground seismic survey interpretation, the sedimentary sequence of these basement-high areas are categorized into 3-4 sedimentary facies (Fig. 4.1 b).

Krabang-1 well was located in the north-eastern basement-high area. This basement-high area is the ridge between the Sakon and Paknam basins (Figs.3.2.2& 4.1. c). The sedimentary sequences in this basement-high area comprise of 3 sedimentary facies, namely, sedimentary facies 1, 2 and 3 in descending order (Figs. 4.1 d & e). The basal facies is sedimentary facies-3 overlying the pre-Tertiary limestone basement. The thickness of this facies is approximately 800-1,000 feet. The sedimentary facies-3 consists of thick to very thick bedded sandstone of variable colours interbedded with red and brown shale. The sedimentary facies-2 or middle facies overlies the Late Miocene unconformity which is the upper boundary of the sedimentary facies-3. The middle facies consists of thick to very thick bedded of sandstone of variable colours interventing by yellow clay. The thickness of this facies is approximately 1,000 feet. The

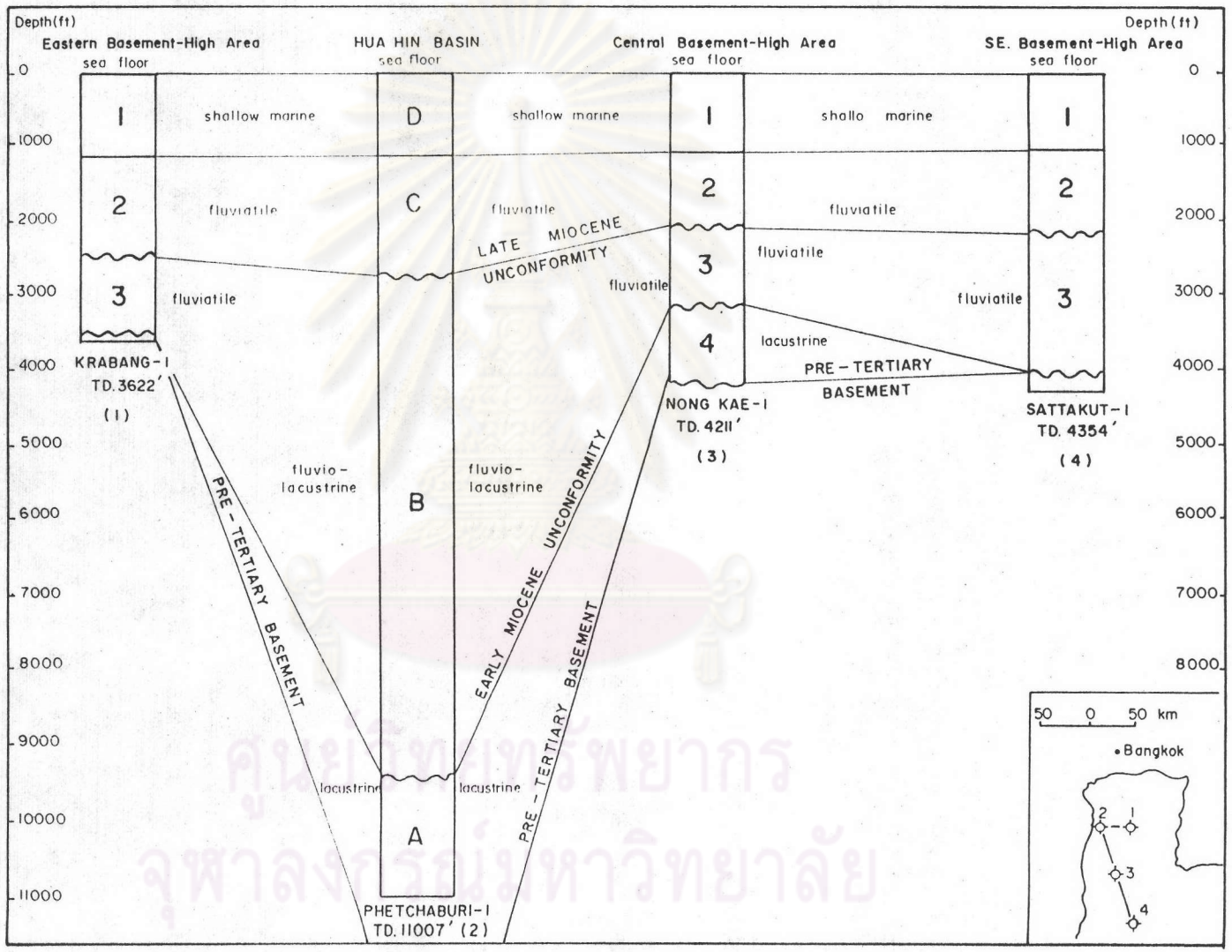

Figure 4.1 b The sedimentary facies in the Upper Gulf of Thailand.

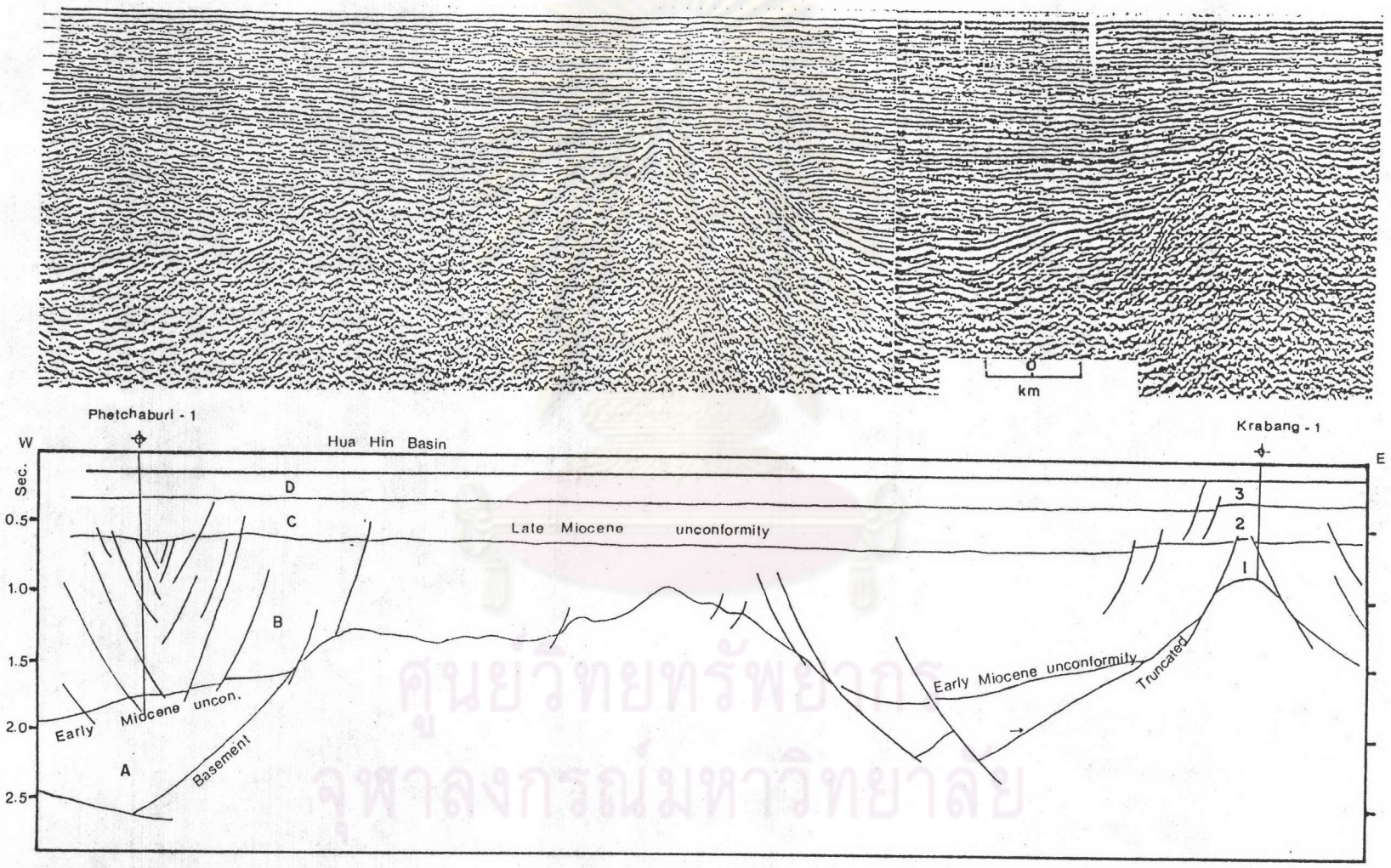

Figure 4.1 c The seismic section and geological section along the E-W direction (seismic line no. 26A,26,see Fig. 3.a for location) of the Hua Hin basin showing of the location of the Phetchaburi-1 and Krabang-1 wells.

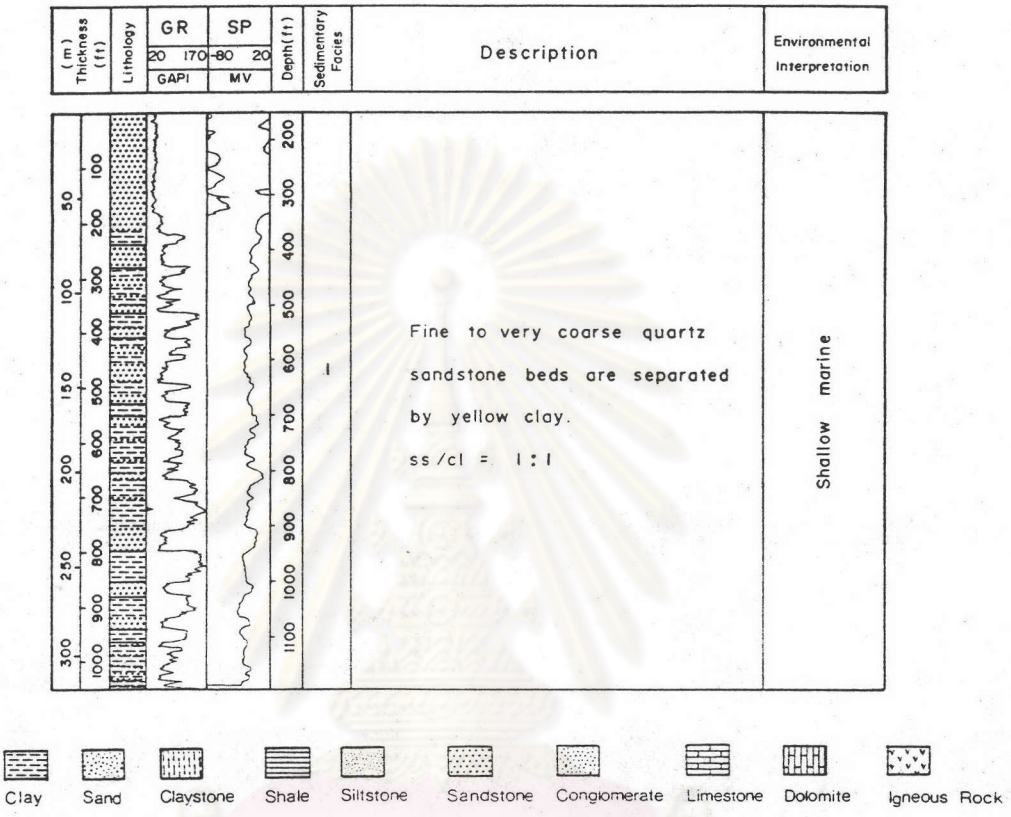

Figure 4.1 d Summarized characteristics of Krabang-1 well.

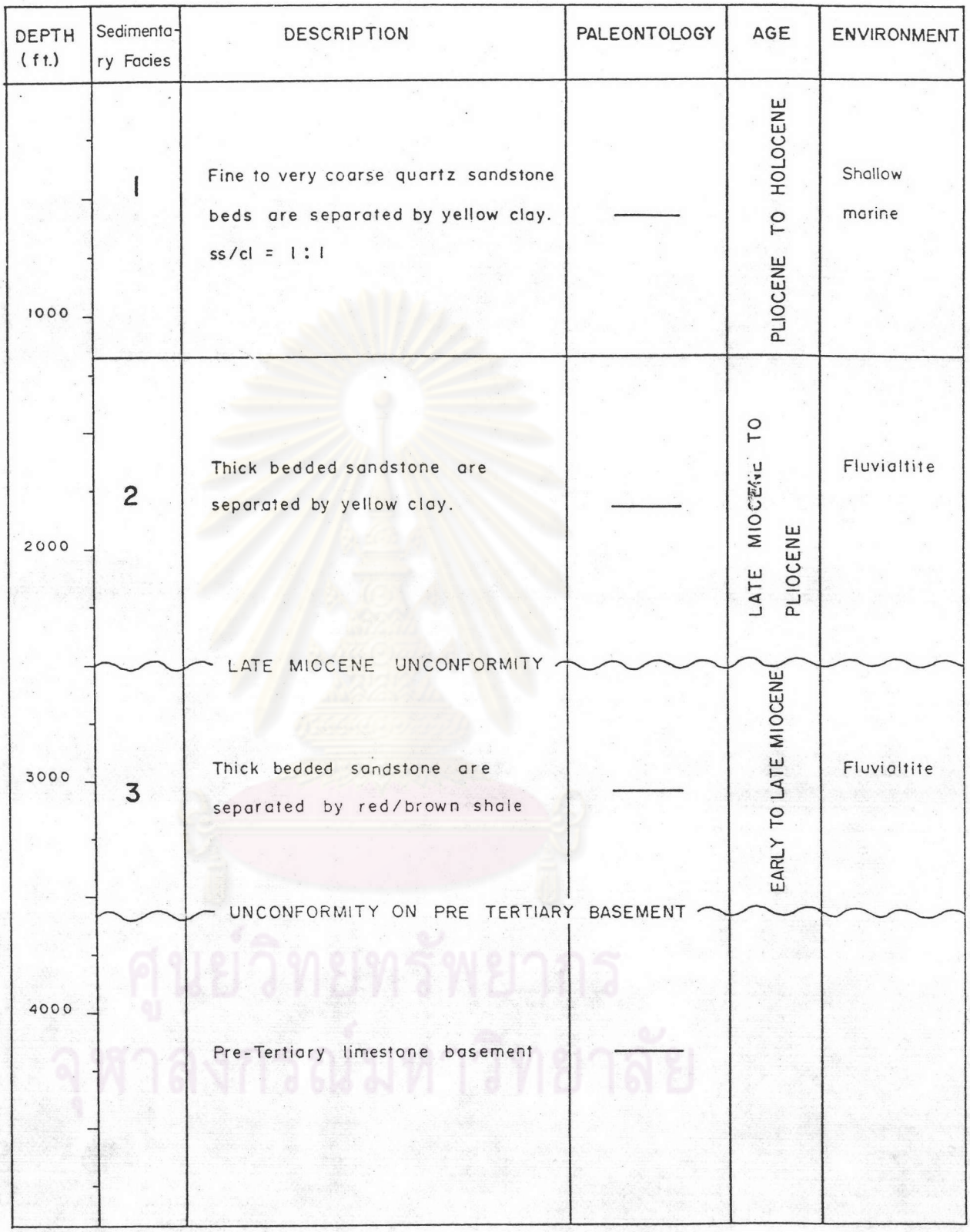

Figure 4.1 e Summarized characteristic of Krabang-1 well.

top facies or the sedimentary facies-1 overlies unconformably? the sedimentary facies-2. The sedimentary facies-3 is characterized by the thick to very thick bedded sandstone interbedding with yellow clay. This facies is approximately 1,000 feet thick. There are no record of palynological evidence in the Krabang-1 well.

The environmental reconstruction of sediments overlying the north-eastern basement-high area is represented by the sedimentary facies analysis of the Krabang-1 well. This analysis is based primarily on lithology, sedimentary structure and external geometry suggesting that the fluviatile environment was dominated in this basement-high area. The basal facies or sedimentary facies-3 consists of the interbedding of sandstone and shale with the sand/clay ratio of 1:1. The external geometry of this facies is tabular. The middle facies is characterized by the interbedding of sand and clay, and the external geometry is tabular. For the middle and basal facies, only the short lithological characteristic report of the Pecten Company and the information of the external geometry without lithological and geophysical logs are used to as compared with the facies models of Walker (1984), Reading (1979), Selley (1980), Miall (1982), and Davis (1983). They are concluded to be the fluviatile environment. In the upper facies of this basement-high area as compared with the facies model of walker (1984), Reading (1979), Selley (1980), Miall (1982) and Davis (1983) and are concluded to be the shallow marine environment.

Comparing the sedimentary facies of the north-eastern basement-high area with the sedimentary facies of the Hua Hin basin, the sedimentary facies-3 was deposited during the same time as

sedimentary facies A and B. Similarly, the sedimentary facies-2 and facies-1 were deposited during the same time with the facies C and D, respectively (Fig. 4.1 f). Initially, the thick sediments of lacustrine and fluvio-lacustrine were deposited in the Hua Hin basin whereas on the basement-high area the activities of the fluvialtile system were dominated. However, there was an interruption of sedimentation in the lower part of the Hua Hin basin by the uplifting and erosion as represented by the angular unconformity of Early Miocene age between the lower lacustrine facies and upper fluvio-lacustrine facies. Thereafter, the fluviatile environment was dominated in the Hua Hin basin and on the north-eastern basement-high area over the Late Miocene disconformity. The final, the marine environment entirely dominated over the study area and still active to the present day. In brief, the sedimentation within the half-graben were under the influence of lacustrine to fluvio-lacustrine, fluviatile and marine environments in ascending order, whereas the sedimentation over the north-eastern basement-high area, were under the influence of fluviatile environment in lower part and the marine environment in the upper part.

The Nong Kae-1 well was located in the central basement-high area of the Upper Gulf of Thailand. The area is the ridge between the Hua Hin basin and the N-Western basin in the Upper Gulf (Fig.4.1 g). The sedimentary sequence in this basement-high area can be subdivided into 4 sedimentary facies , namely, sedimentary facies 1, 2, 3 and 4 in descending order (Figs.4.1 h&i). The sedimentary facies-4 is the basal facies overlying the pre- Tertiary basement rocks. The geometry of this facies is lens-shape with maximum thickness of approximately

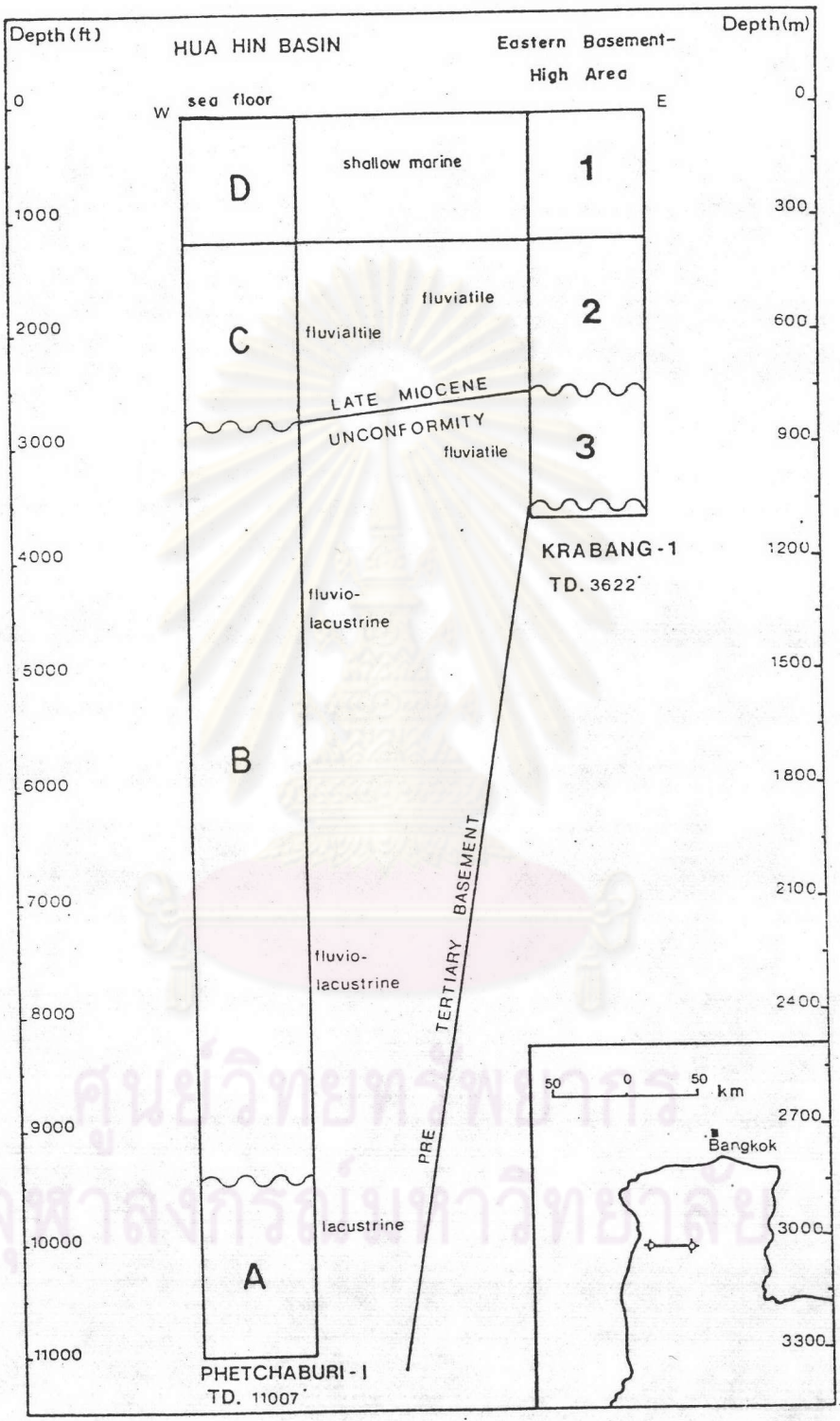

Figure 4.1 f˙ Stratigraphic correlation of the Hua Hin basin and the north-eastern basement-high area.

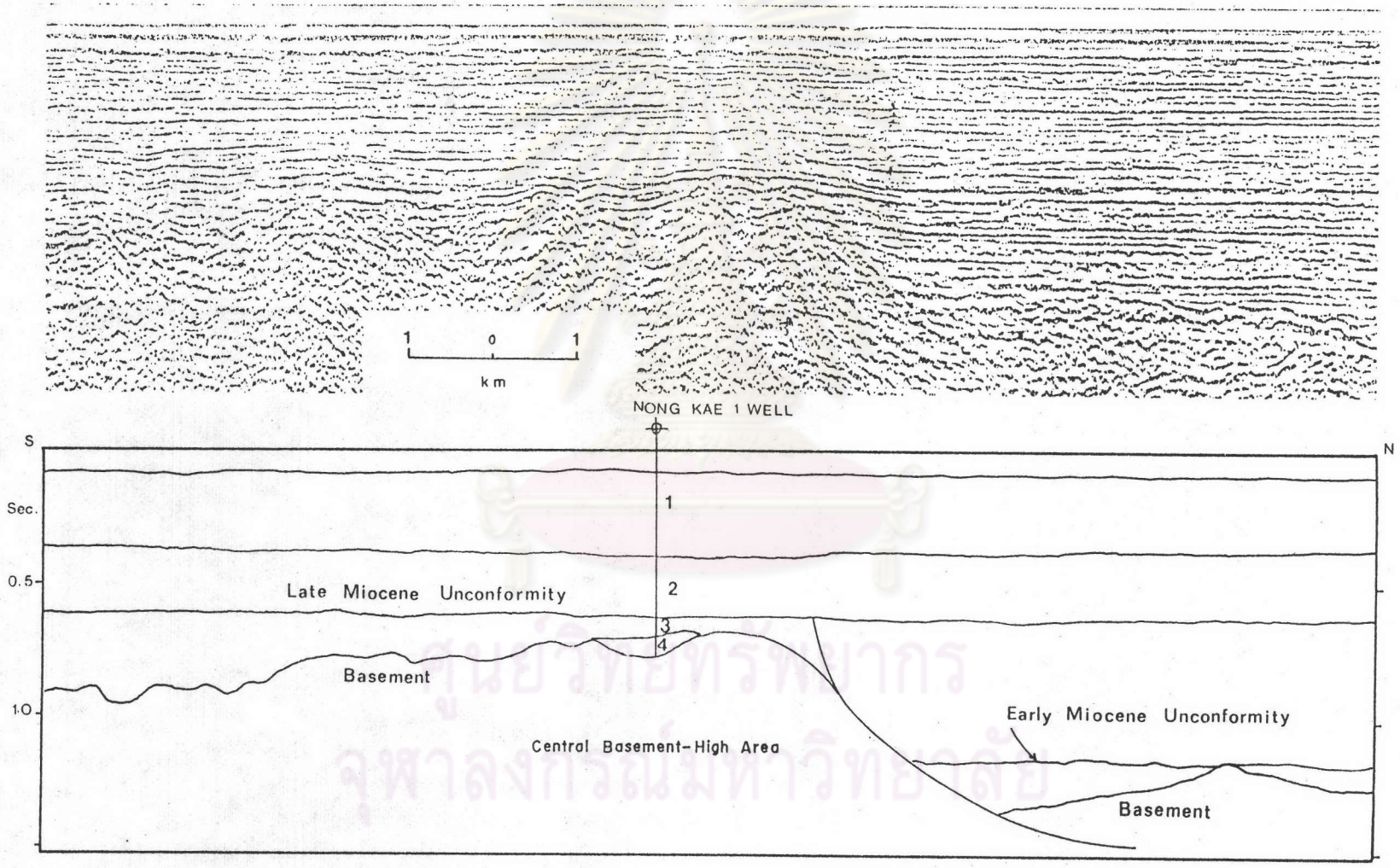

Figure 4.1 g The seismic section and geological section along the N-S direction(seismic line no.17 ,see Fig. 3.a for location) of study area showing the location of the Nong Kae-1 well.

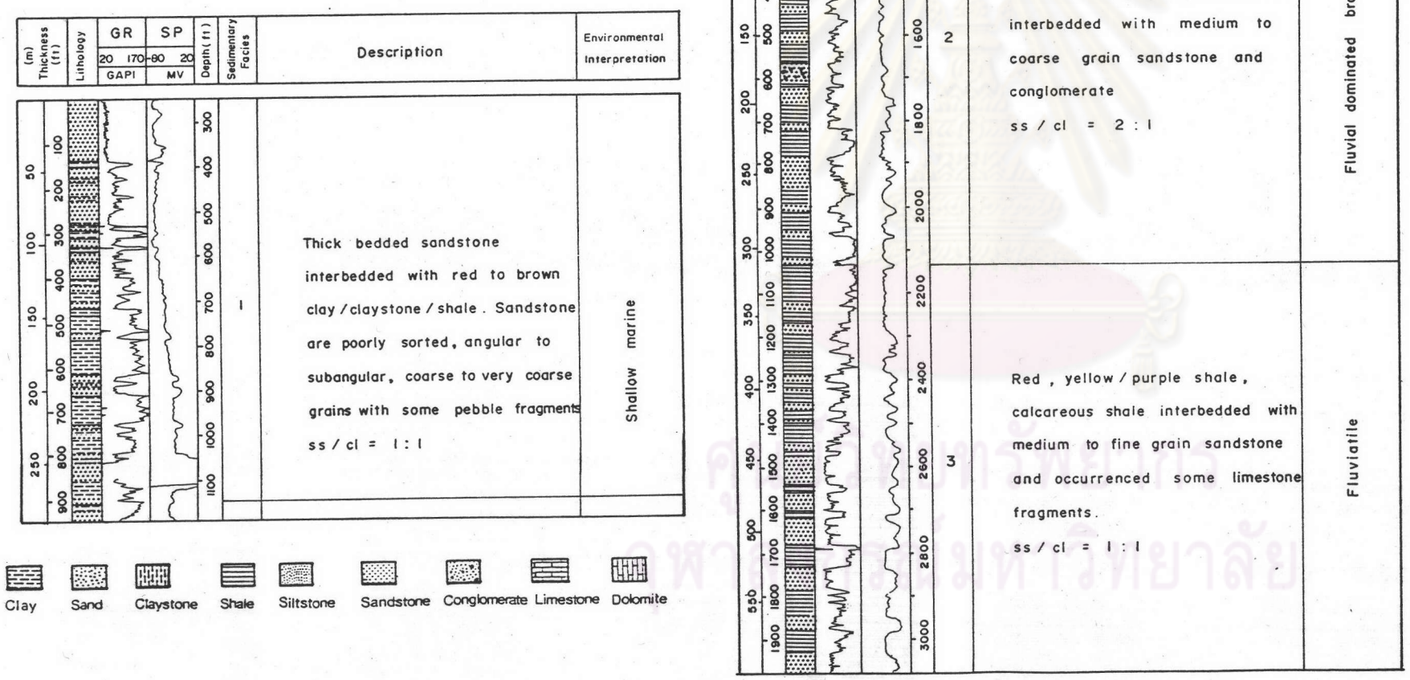

Figure 4.1 h Summarized characteristics of Nong Kae-1 well.

DEPTH (ft.)	Sedimentary Facies	DESCRIPTION	PALEONTOLOGY	AGE	ENVIRONMENT
1000	1	Thick bedded sandstone interbedded with red to brown clay/claystone/ shale. Sandstone are poorly sorted, angular to subangular, coarse to very coarse grains with somoe pebble fragments. ss/cl = 1:1	——	PLIOCENE TO HOLOCENE	Shallow marine
2000	2	Red/brown, grey, yellow shale interbedded with medium to coarse grain sandstone and conglomerate ss/cl = 2:1	——	LATE MIOCENE TO PLIOCENE	Fluvial dominated braided stream
		LATE MIOCENE UNCONFORMITY			
3000	3	Red, yellow/purple shale, calcareous shale interbedded with medium to fine grain sandstone and occurrenced some limestone fragments. ss/cl = 1:1	2968' tricolpates Age : Tertiary	EARLY MIOCENE TO LATE MIOCENE	Fluvialtite
		EARLY MIOCENE UNCONFORMITY			
4000	4	Grey, brown limestone interbedded with thin red, brown shale beds. lst/cl = 2:1	3440 - 3550' dictyoconus sp. Age : Eocene to Early Miocene	OLIGOCENE TO EARLY MIOCENE	Lacustrine
		UNCONFORMITY ON PRE-TERTIARY BASEMENT			
		Pre-Tertiary basement rocks			

Figure 4.1 i Summarized characteristics of Nong Kae-1 well.

1,000 feet. The characteristics of this facies is mainly the interbedding of grey to brown limestone with red to brown shale. Overlying the basal facies is the sedimentary facies-3 with approximately 1,000 feet thick. The sedimentary facies-3, with tabular geometry, overlies the Early Miocene Unconformity. The sedimentary facies-3 consists of red, yellow shale, calcareous shale and medium- to fine-grained sandstone. The characteristic of this facies is the series of fining upward sequence. The sand/clay ratio of the sedimentary facies 3 is 1:1. The sedimentary facies-2 overlies sedimentary facies-3 with the Late Miocene Unconformity in between. The sedimentary facies-2 is characterized by red, brown, grey and yellow shale interbedded with medium- to coarse- grained sandstone with some conglomerates, with sand/clay ratio of 1:2. The uppermost facies unconformably? overlies the sedimentary facies-2. The sedimentary facies-1 is approximately 1,000 feet thicks. The sedimentary facies-1 is characterized by thick bedded sandstone interbedded with red to brown clay. The ratio of sand/clay is 1:1. The overall geometry of this facies is tabular. There are palynological evidences the Nong-Kae-1 well at the depth of 3,440-3,550 feet and 2,968 feet in sedimentary facies-4 and sedimentary facies-3, respectively. From sidewall core at the depth of 3,340-3,550 feet, dictyoconus sp. are identified and referred to as Eocene to Early Miocene in age. At the depth of 2,968 feet, the pollen of tricolpates are represented Tertiary age.

The environmental reconstruction of sediments overlying the central basement-high area is based on the sedimentary facies analysis of the Nong Kae-1 well. This analysis is focusing primarily

on lithology, sedimentary structure and external geometry. The basal facies overlies the pre- Tertiary basement rocks as compared with the facies models of Picard and High (1972,1981), Reading (1919) and Davis (1983) is concluded to be lacustrine sediments of shale interbedded with limestone and sandstone. This facies is the lowermost part of the Cenozoic sequence which was deposited only in the depression of the central basement-high area. The external geometry of this facies is wedge -lens shape. The lacustrine sediments of the basal facies is overlain by the sedimentary facies-3. The sedimentary facies-3 as compared with the facies models of Walker (1984), Reading (1979), Selley (1980), Miall (1982) and Davis (1983) is considered to be the channel bank and floodplain of meandering stream of fluviatile environment. This sedimentary facies is characterized by interbedding of sandstone and shale. The external geometry of this facies is tabular. The unconformity between sedimentary facies-4 and sedimentary facies-3 is defined as Early Miocene in age. After the fluviatile sedimentation of the sedimentary facies-3 the sedimentary facies-2 was deposited in this basement-high area. As compared the sedimentary facies-2 with the facies models of Allen (1965), Walker (1984), Reading (1979), Selley (1980), Miall(1982) and Davis (1983) this facies is concluded to be deposited under the braided stream of fluviatile environment. This sedimentary facies is composed of shale interbedded with sandstone with the sand/clay ration is 2:1. The sandstone is characterized by medium- to coarse-grained with some conglomerates. The uppermost facies is facies-1 as compared with the facies models of Reading (1979), Selley (1980), Miall (1982), Davis (1983), Walker (1984) and MaCave (1985),and is concluded to be shallow marine environment. facies is

the shallow marine environment.

Comparing the sedimentary facies of the central basement-high area with those of the Hua Hin basin (Fig.4.1 j), these are differences both in thicknesses and depositional environments. The sedimentary facies-4 was deposited only in the depression of the central basement-high area while the facies A of relatively greater thickness was deposited in the deepest part of the Hua Hin basin under similar lacustrine environment. Afterthat, in the Hua Hin basin the thick sediments of fluvio-lacustrine of the facies B was deposited whereas in the central basement-high area the fluviatile sediments were dominated in the sedimentary facies-3. Afterthat, the fluvialtile environment were dominated throughout the Upper Gulf represented by facies C in the Hua Hin basin and sedimentary facies-2 in the central basement-high area. The uppermost sedimentary sequence of the study area is represented by the shallow marine sediments as defined by the facies D in the Hua Hin basin and the sedimentary facies-1 in the central basement-high area.

The Sattakut -1 well was located in the south-eastern basement-high area of the Upper Gulf of Thailand. This basement-high area is the ridge between the N- Western basin and the Ko Kra basin (Fig.4.1 k). The sedimentary sequence in this basement-high area can be subdivided into 3 sedimentary facies, namely, sedimentary facies 1, 2 and 3 in descending order (Figs. 4.1 l&m). The pre- Tertiary basement rocks are the massive bedded limestone interbedded with red, brown shale. The basement rocks are Permain rocks which are defined from fossils which present in these rocks ,such as, the fusulinid at 4,265 feet, crinoid columnar at 4,307 feet and fenestellid bryozoa at

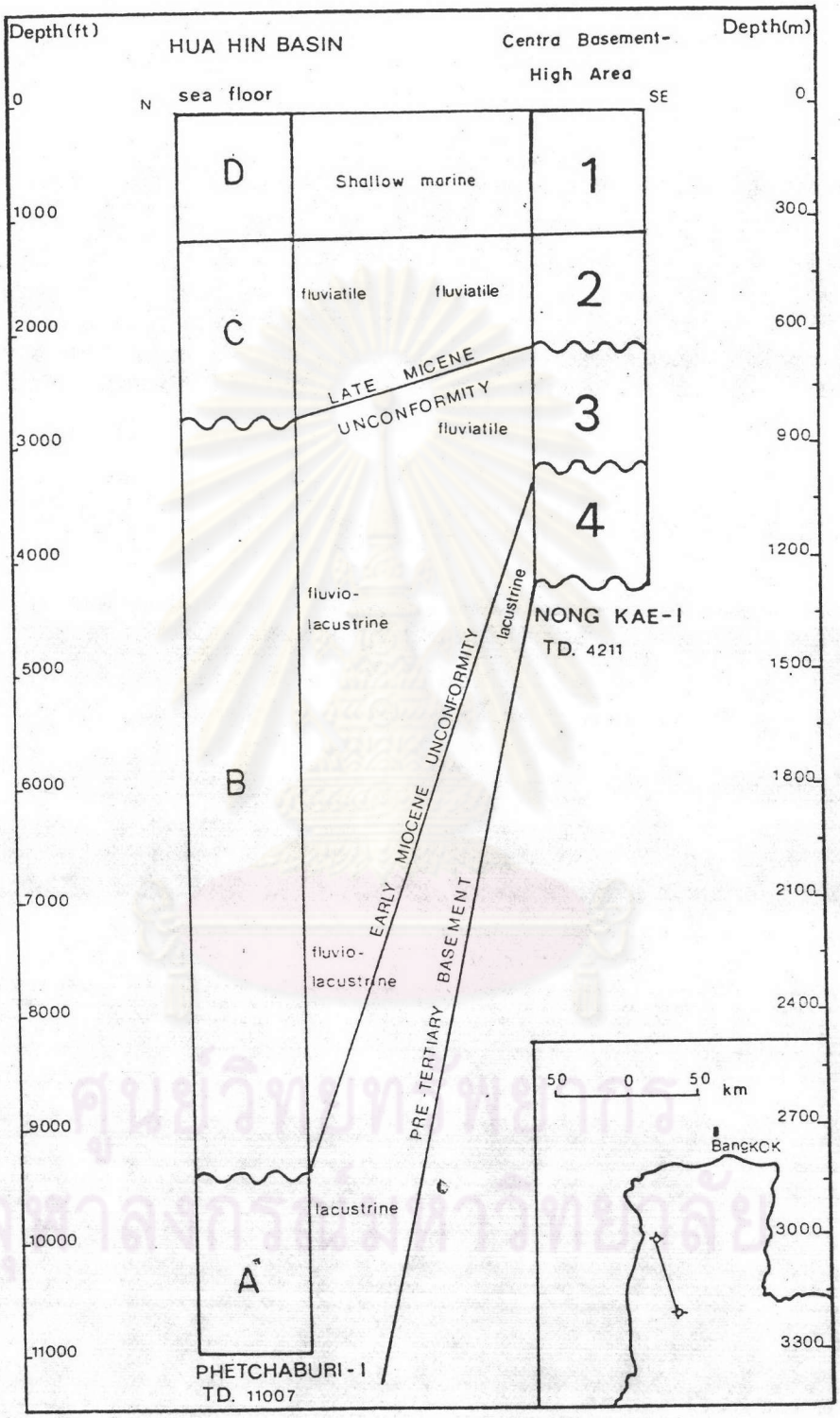

Figure 4.1 j Stratigraphic correlation of the Hua Hin basin and Central basement-high area.

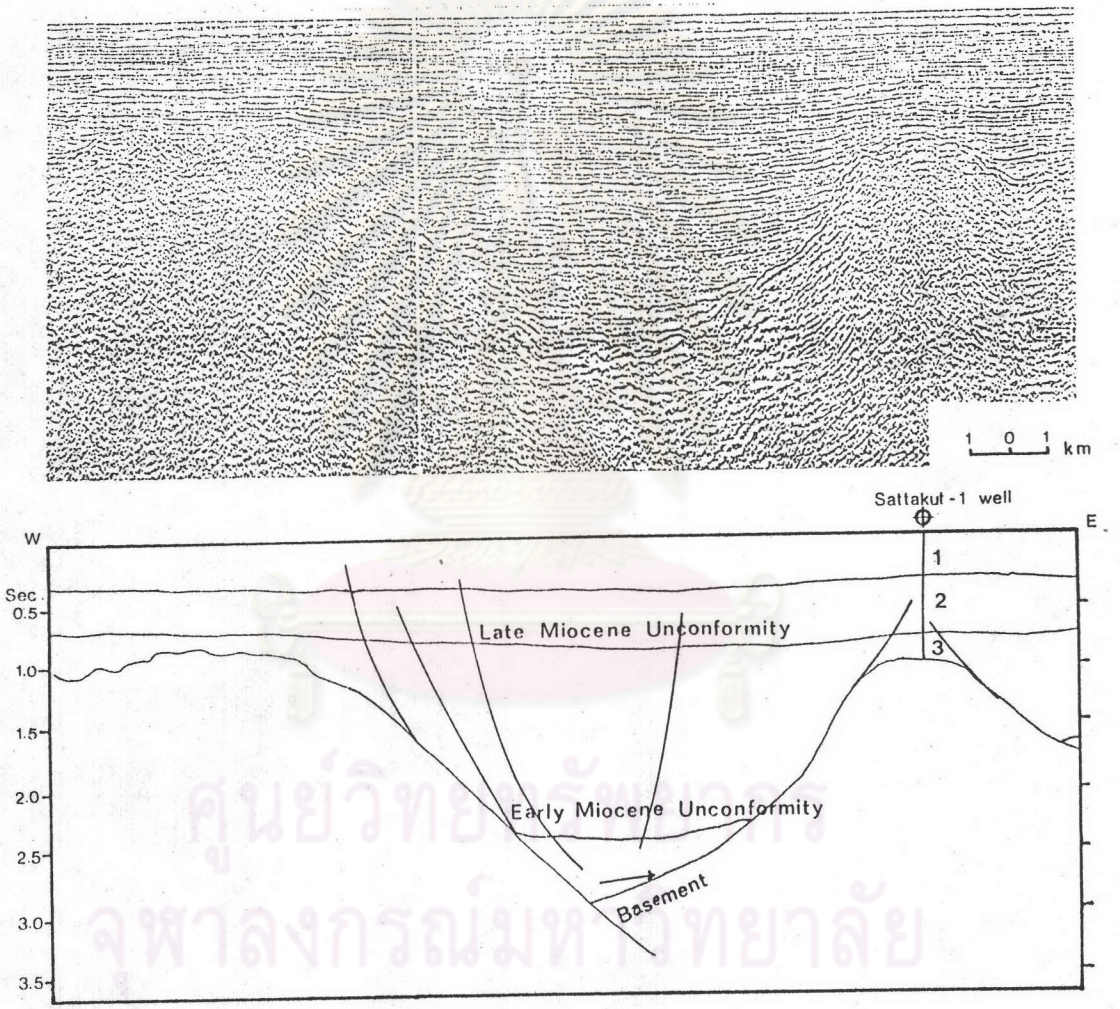

Figure 4.1 k The seismic section and geological section along the E-W direction (seismic line no.78, see Fig. 3a for location) of the study area showing the location of the Sattakut-1 well.

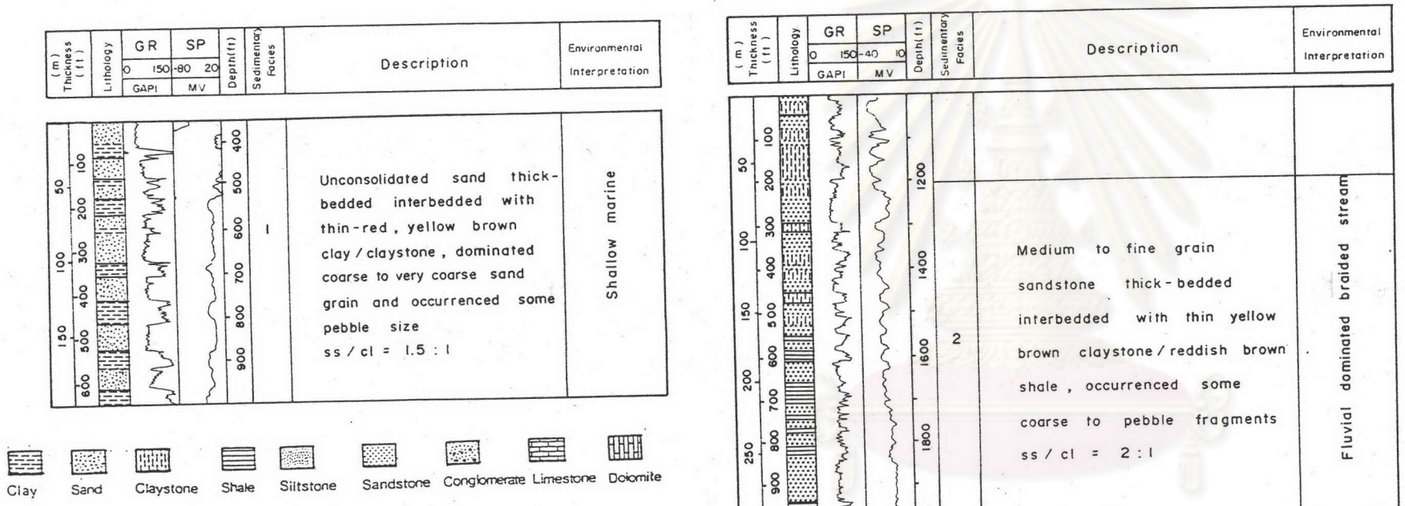

Figure 4.1 1 Summarized characteristics of Sattakut-1 well.

DEPTH (ft.)	Sedimentary Facies	DESCRIPTION	PALEONTOLOGY	AGE	ENVIRONMENT
1000	1	unconsolidated sand thick-bedded interbedded with thin-red, yellow brown clay/claystone, dominated coarse to very coarse sand grain and occurrenced some pebble size ss/cl = 1.5 : 1	—	PLIOCENE TO HOLOCENE	Shallow marine
2000	2	medium to fine grain sandstone thick-bedded interbedded with thin yellow brown claystone/reddish brown shale, occurrenced some coarse to pebble fragments ss/cl = 2 : 1	—	LATE MIOCENE TO PLIOCENE	fluvial dominated braided stream
		LATE MIOCENE UNCONFORMITY			
3000	3	medium to fine grain sandstone thick-bedded interbedded with thin to thick red brown shale calcareous shale, limestone fragments and some grey to dark shale, trace to coal, ss/cl = 1 : 1	—	EARLY TERTIARY TO LATE MIOCENE	fluvial dominated meandering stream
4000		UNCONFORMITY ON PRE-TERTIARY BASEMENT			
		thick, massive bedded limestone interbedded with red brown shale	4265′ fusulinid 4307′ crinoid columnars 4329′ fenestellid bryzoa Age : Permian	PERMIAN	

Figure 4.1 m Summarized characteristics of Sattakut-1 well.

4,329 feet. The basal facies is the sedimentary facies-3 overlying the pre-Tertiary basement rocks. The geometry of this facies is len-shape with maximum thickness of approximately 1,800 feet. The characteristics of this facies is the series of fining upward of medium- to fine -grained sandstone with reddish brown shale, calcareous shale and trace of coal, limestone fragment in some parts. The sand/ clay ratio of this facies is 1:1. The sedimentary facies-2 overlies unconformably the sedimentary facies-3 and approximately 1,000 feet thick. The external geometry of this facies is tabular. The characteristics of facies-2 is the interbedding of medium- to fine-grained sandstone with yellow brown claystone and reddish brown shale and some coarse to pebble fragments. The sand /clay ratio of this facies is 2:1. The uppermost facies unconformably? overlies the sedimentary facies-2. The sedimentary facies-1 which is approximately 1,000 feet thicks. The sedimentary facies-1 is characterized by the interbedding of the unconsolidated sand with red, brown clay/claystone. The external geometry of this facies is tabular. The sand/clay ratio of this facies is 1:1. There are no record of palynological evidence along the Cenozoic sequence in the south-eastern basement-high area.

The environmental reconstruction of sediments overlying the south-eastern basement-high area is base on the sedimentary facies analysis of the Sattakut-1 well. This analysis is focusing primarily on lithology, sedimentary structure and external geometry suggesting that the fluvialtile environment was dominated in this basement-high area. The sedimentary facies-3 is the basal facies of the Cenozoic sediments which is deposited in this basement-high area. The basal

facies overlies the pre-Tertiary basement rocks as compared with the facies models of Allen (1964), Reading (1978), Selley (1980), Miall (1982), Davis (1983) and Walker (1984), and is considered to be deposited under the fluviatile environment with dominated braided stream. The fluviatile sediments of the basal facies is overlain by the sedimentary facies-2. The sedimentary facies-2 as compared with the facies models of Allen (1964), Reading (1978), Selley (1980), Miall (1982), Davis (1983) and Walker (1984), and is concluded to be the fluviatile environment with dominated braided stream. The uppermost facies is facies-1 as compare with the facies models of Reading (1979), Selley (1980), Miall (1982, Davis (1983), Walker (1984) and MeCave (1985), and is concluded to be shallow marine environment.

Comparing the sedimentary facies of the south-eastern basement-high area with those of the Hua Hin basin, these are difference both in thickness and depositional environment. The basal facies was deposited during the same time of the facies A and B deposited and the sedimentary facies-2 and sedimentary facies-1 were deposited the same time with the facies C and D (Fig.4.1 n). In the Hua Hin basin the thick sediments of lacustrine and fluvio-lacustrine were dominated deposited whereas in the high area the coarse-grained of the fluviatile environment were persistent. The sedimentary facies-1 is the uppermost facies which was deposited the same time with the facies D and in the same environment as shallow marine environment.

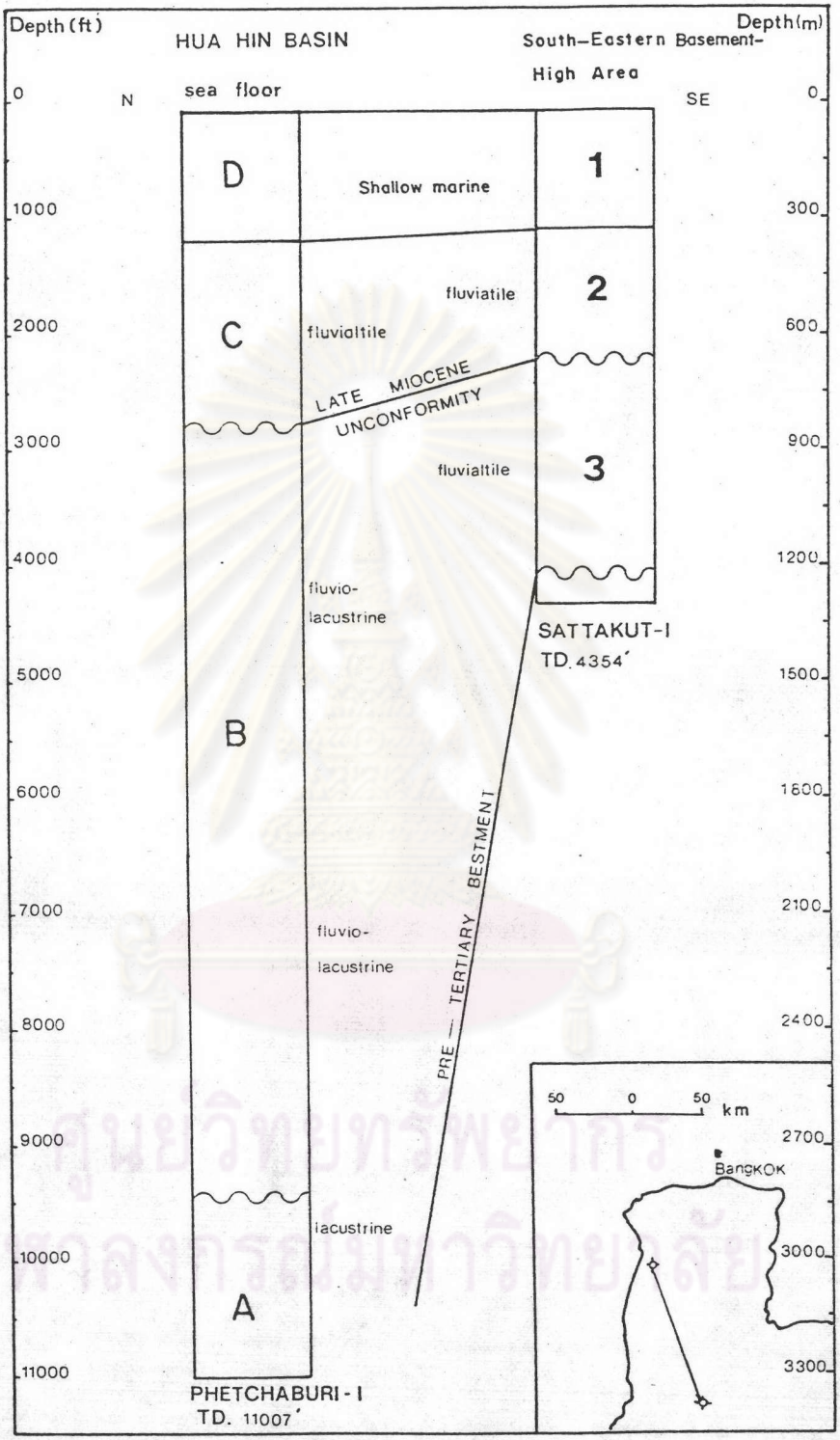

Figure 4.1 n Stratigraphic correlation of the Hua Hin basin and the south-eastern basement-high area.

4.2 Proposed Lithostratigraphy of the Upper Gulf of Thailand

The understanding of depositional systems from the standpoint of modern sedimentary environments and from the rock record requires expertise in both sedimentology and in stratigraphy. In a general way, the study of rock record demands equal both sedimentology and stratigraphy, whereas in the modern environment requires more sedimentology than stratigraphy. One of the primary tasks for the successful understanding of depositional systems is the ability to visualize modern environments as they would appear in the rock record to interpret the paleoenvironments represented by the rocks preserved in the stratigraphic record. The modern "soft-rock" geologist must be able to do this continually and must be equally competent both in modern sedimentary environments and in analyzing their resultant features in the rock record.

There is obvious relationship between the environment of deposition and the nature of the sediment deposited. For the geologist working with ancient sedimentary rocks, the primary data of rock and the environment must be interpreted. The lithostratigraphic unit is the fundamental type of stratigraphic unit which used to described and divide the rocks. Lithostratigraphic unit is a body of rock strata that is defined by consisting dominantly of a certain lithological type, or combination of lithological types, or by processing other impressive and unifying lithological features. It may consist of sedimentary, or igneous, or metamorphic rocks, or in some cases, of intricate interbedding of two or more of these. It is a three dimensional body and its concept must be based on its character as a unit through its full extent, both vertically and

laterally (American Commission on Stratigraphic Nomenclature, 1961).

In this study, the stratigraphic framework of the Upper Gulf has been established from the examination of cutting sample, paleontological data, wireline logs which are used to establish the sedimentary facies, environment of deposition and stratigraphic correlation between wells. The lithostratigraphic units used in this study cover the group, the formation and member. The nomenclature of various lithostratigraphic units had been proposed as informal name to serve the discussion. The Hua Hin Group is a name proposed in this study for the Cenozoic sedimentary rocks beneath the Late Miocene Unconformity of the Upper Gulf of Thailand which has been studied in detail in the Hua Hin basin and adjacent areas. Unconformably overlies the Hua Hin Group is the Choa Phraya Group (Fig. 4.2). The Choa Phraya Group is a name for the Cenozoic sediments which were deposited above the Late Miocene Unconformity in the Gulf of Thailand (Pradidtan et. al, 1990).

4.2.1 The Hua Hin Group

It is proposed in this study that the Group comprises of 2 formations, namely, Nong-Kae Formation and Phetchaburi Formation, in ascending order deposited under the lacustrine environment and fluvio-lacustrine environment, respectively.

4.2.1.1 Nong-Kae Formation

This formation is the lowermost lithostratigraphic unit of the Hua Hin Group which overlies pre- Tertiary basement in the basins of the Upper Gulf, such as, Hua Hin basin and small basin of the

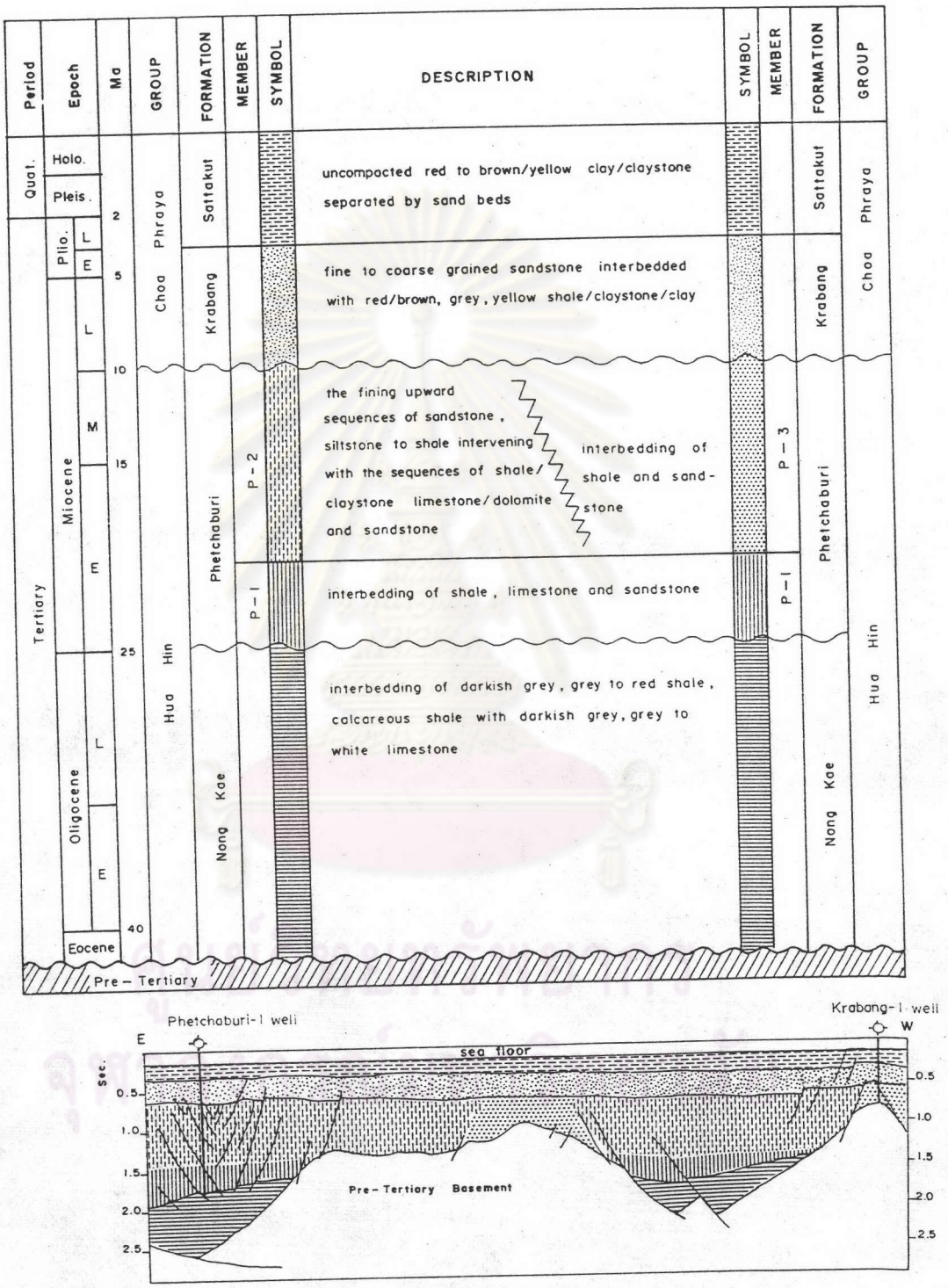

Figure 4.2 Summarized stratigraphic framework in the Gulf of Thailand.

Central High Area. Therefore, this formation is only present in the grabens or half-grabens and is entirely absent above the horsts of the study area. The type of the unconformity between this formation with the pre- Tertiary basement-rocks is believed to be angular unconformity. The lithology of this formation is characterized by the interbedding of darkish grey, grey to red shale, calcareous shale with grey to white limestone. The thickness of this formation ranges from 300 to 2,800 metres. The geometry of this formation is concluded to be wedge-lens shape with varying thicknesses. This formation is deposited under the lacustrine environment.

4.2.1.2 Phetchaburi Formation

Within the sub-basins of the Upper Gulf, the Phetchaburi Formation overlies unconformably the Nong-Kae Formation with abrupt change in lithological characteristics and the angular unconformity. In the basement-high areas, this formation overlies unconformably the pre- Tertiary basement-rocks and the type of the unconformity is the angular unconformity. The lithological characteristics of this formation deposited in the grabens are interbedding of shale and limestone in the lower part and a series of fining-upward sequence of sandstone, siltstone and shale, intervening with the sequences of shale/claystone limestone/dolomite and sandstone in the upper part. In the basement-high areas, the lithological characteristics of this formation is generally shale interbedded with sandstone. The formation is widespreadly distributed over the Upper Gulf. The thickness of the formation is over 1,500 metres in the grabens and half- grabens and ranges from 300 to 600 metres in the basement-high area. The geometry of this formation is the wedge-shape or tabular

with varying thicknesses. This formation was deposited under the fluvio-lacustrine and fluviatile environments.

Phetchaburi Formation can be further subdivided into the P-1 Member, P-2 Member and P-3 Member in ascending order. The P-1 Member is the facies which was deposited over the Early Miocene Unconformity above the Nong-Kae- Formation in the Hua Hin basin and adjacent areas of the Upper Gulf. The characteristics of this member is the interbedding of shale, limestone and sandstone of the lacustrine facies. The geometry of this member is wedge-shape and is only distributed in the deep part of basins. The P2-Member conformably overlies the P-1 Member with abrupt chang in lithology. The member is represented by the fluvio-lacustrine facies. The lithological characteristics of this member is a series of fining-upward sequences of sandstone,siltstone to shale intervening with the sequence of shale/claystone limestone/dolomite and sandstone. The geometry of the member is tabular and is distributed in the upper part of the of the Upper Gulf. The P-3 Member is distributed only in the basement-high area with lateral facies change from the P-2 Member. This formation is deposited under the fluviatile environment and generally characterized by the interbedding of shale and sandstone. The thickness of this formation ranges from 300 to 600 metres.

4.2.2 The Choa Phraya Group

In this study the Choa Phraya Group is represented by 2 formations, namely, Krabang Formation and Sattakut Formation in ascending order. The Krabang Formation was deposited under the fluviatile environment, whereas the Sattakut Formation was deposited

under the shallow marine environment.

4.2.2.1 Krabang Formation

This formation is predominantly characterized by the association of fine- to coarse-grained sandstone interbedded with red,brown, grey, yellow shale/claystone/clay. The formation overlies the Phetchaburi Formation with the Late Miocene unconformity in between. The geometry of this formation is tabular and the thickness is between 300-500 metres. The formation is distributed throughout the Upper Gulf of Thailand and was deposited under the braided /meandering fluviatile environment.

4.2.2.2 Sattakut Formation

This formation is the uppermost lithostratigraphic unit of the Hua Hin Group. It overlies conformably the Krabang Formation and is generally characterized by the association of sand and clay/claystone deposited under marine shelf environment. The formation is wide-spreadly distributed throughout the study area. The external geometry of the formation is rather uniform tabular and the thickness is approximately 300-400 metres.

4.3 Geological Evolution of the Upper Gulf of Thailand

Despite the fact that the development of basins in the Upper Gulf of Thailand is generally believed to have been formed during Late Cretaceous to Early Tertiary, many lines of evidence indicate that the oldest sediments in the Upper Gulf is of Eocene to Miocene in age. The sediments in the Upper Gulf are mainly non-marine clastics of Paleogene age covered by the marine sediments of Late

Neogene to Quarternary age.

During Paleogene Period, a few basins were developed in the Upper Gulf. The listric normal faults control the formation and directions of these basins. The lacustrine sediments were deposited in the lowermost part of these basins overlying unconformably the pre- Tertiary basement rocks. This lacustrine unit is generally characterized by the interbedding of shale with limestone. The basins with intervening basement-high areas were formed by the rotation fault-blocks and the reactivation of existing major listric normal faults during early Oligocene to early Miocene which culminated a depression of limnic condition. Therefore, during Early Oligocene to Early Miocene , there was the paleo-lakes developed in the Upper Gulf of Thailand.

The Early Miocene Unconformity ,only present in the basins, is the result of the renewed tectonic activity of major fault zones in this region and the sea-floor spreading of Andaman sea which cause the uplift, erosion and rifting in these basins. During Early to Late Miocene time, these basins continues to subside and were accumulated by the thick unit of the fine-grained clastics, limestone and medium-grained clastics of the fluvio-lacustrine facies. At the same time, the fluviatile sediments were deposited in the basement-high areas overlying unconformably the basement rocks. Therefore, at that time when the paleo-lakes were formed in the basins of the Upper Gulf, and influence of the fluvialtile environment was dominated over the basement-high area.

During the late Miocene time, the normal faults were ceased and marked by the abrupt disappearance of the paleo-lakes in basins in the Upper Gulf, then the Late Miocene Unconformity is defined at that time. This unconformity is well-known and wide-spreadly distributed throughout the SE Asia. The sedimentary unit overlying this unconformity is characterized by fine-to coarse-grained clastics of fluviatile facies. The sediments were accumulated throughout the Upper Gulf and are overlain by the uppermost unit of shallow marine facies.

The marine transgression in the southern part of the Gulf of Thailand is believed to be initiated during Late Miocene. However, during Late Pliocene, the marine transgression in the Lower Central Plain and the Upper Gulf encroached throughout the Upper Gulf and is represented by the shallow marine facies of the uppermost part in this area. This facies is characterized by fine-to medium-grained clastics and deposited wide-spreadly throughout the Upper Gulf. The major marine regression of world-wide glaciation have been effected the shallow sea of the SE Asia during the Pleistocene. The last marine transgression of the Upper Gulf is believed to be during the Middle Holocene time. The last tectonics related to the study area is the emergence of the lower Central Plain a few metres from the sea during the Holocene time. Then ,during Late Pliocene to Holocene the shallow marine facies is deposited in the uppermost part of the Upper Gulf,and is still represented as the shallow marine surficial deposits in the present day.

Due to the fact that, overall configuration of the Upper Gulf of Thailand is not a simple one ,but complicated by different

architecture of basins. Therefore, the sedimentation patterns and the depositional environments within this area vary considerably from place to place. Howevers, it is noted that the broad pattern of sedimentary facies of the Cenozoic sequence within the Upper Gulf reveals that the influence of lacustrine and fluvio-lacustrine are confined essentially to the deep part of the basins and fluvialtile deposits are represented in the basement-high areas and the marine sediments are dominated in the uppermost part.