CHAPTER III

STRATIGRAPHY

In order to reconstruct a depositional system, first of all, we have to define its stratigraphy. The procedures for carrying this out are the subject of this chapter. In this study, an attempt is being made to define the stratigraphy of Tertiary sedimentary sequence in the Wichian Buri sub-basin.

Because of the lack of Tertiary outcrop in the Wichian Buri sub-basin, its detailed stratigraphy was therefore based largely on subsurface data. Lithological data, geophysical log data, palynological data as well as seismic data were used to establish the stratigraphic units, environments of deposition and stratigraphic correlation among six wells which were drilled in the Wichian Buri sub-basin. The stratigraphic establishment is based on lithological and geophysical log data. The lithological interpretation is based on cutting descriptions, sidewall-core descriptions and petrographic studies on sidewall cores. The geophysical logs here are composed of 4 parameters, namely, gamma ray, spontaneous potential, resistivity and sonic logs. Evidence results of palynological, subsurface geological and petrographic data have been used to define the detail of lithostratigraphic boundaries, environments of deposition and to verify the likely age of each unit. More over, seismic data had been used to draw regional boundaries of the depositional sequence which can lead to correlate the depositional sequence through out the basin. Also it can give many details of internal stratigraphic geometry, and these can be interpreted in terms of depositional environment and paleogeography.

Based on subsurface geological information, the sedimentary sequence in the Wichian Buri sub-basin can be subdivided into 4 formations, namely WB-1 , WB-2 , WB-3 and WB-4 Formations in ascending order (Table 3.1). Detailed description of each formation will be discussed as of follows.

WB-1 Formation

- General Consideration

The lowermost Tertiary stratigraphic unit of the Wichian Buri sub-basin is referred to "WB-1 Formation". It overlies unconformably on the Permo-Triassic basement rocks and conformably underlies the WB-2 Formation. From the existing wells drilled in the Wichian Buri sub-basin, the WB-1 Formation has been penetrated in the unpublished, Bo Rang-1 and Si Thep-1 wells but has been absent in the Khao Leng-1 well.

Generally,the WB-1 Formation is an oxidised sedimentary sequence associated with weathered volcanics. The base of the formation is defined by an abrupt offset on the gamma ray and sonic logs, represent by the top of the Permo-Triassic volcanics or metasedimentary rocks of the basement, and its top is defined by a lithological change to a dark, organic-rich claystone dominant sequence of the WB-2 Formation.

The total thickness of the WB-1 Formation varies from 365 m. in the unpublished well to 100 m. in the Bo Rang-1 well. The thickness of the formation seem to be vary rapidly.

Table 3.1 Proposed stratigraphic of the Wichian Buri sub-basin

AGE	FORMATION		THICKNESS	LITHOLOGY	ENVIRONMENT
QUATERNARY	UNNAMED		28 m.	Claystone, sandstone, coal and basalt .	FLUVIAL
PLIOCENE - UPPER MIOCENE	WB-4		230 m.	Predominantly claystone with minor interbeds of sandstone and locally siltstone .	LACUSTRINE
MIDDLE MIOCENE	WB-3		320 m.	Sandstone interbedded with claystone siltstone and minor coal.	FLUVIAL
LOWER MIOCENE to UPPER OLIGOCENE	WB-2	WB-2C	203 m.	Interbedded claystone, sandstone and silstone .	FLUVIAL/LUCUSTRINE
		WB-2B	412 m.	Claystone interbedded with sandstone and siltstone .	FLUVIAL - DELTAIC LACUSTRINE
		WB-2A	645 m.	Predominantly claystone with minnor interbeds of siltstone and locally sandstone .	LACUSTRINE
OLIGOCENE	WB-1		365 m.	Varicoloured claystone with interbeds of sandstone and associated with weathered volcanics .	FLUVIAL
PERMO-TRIASSIC	BASEMENT		232 m.	Metasedimentary and volcanic rocks	

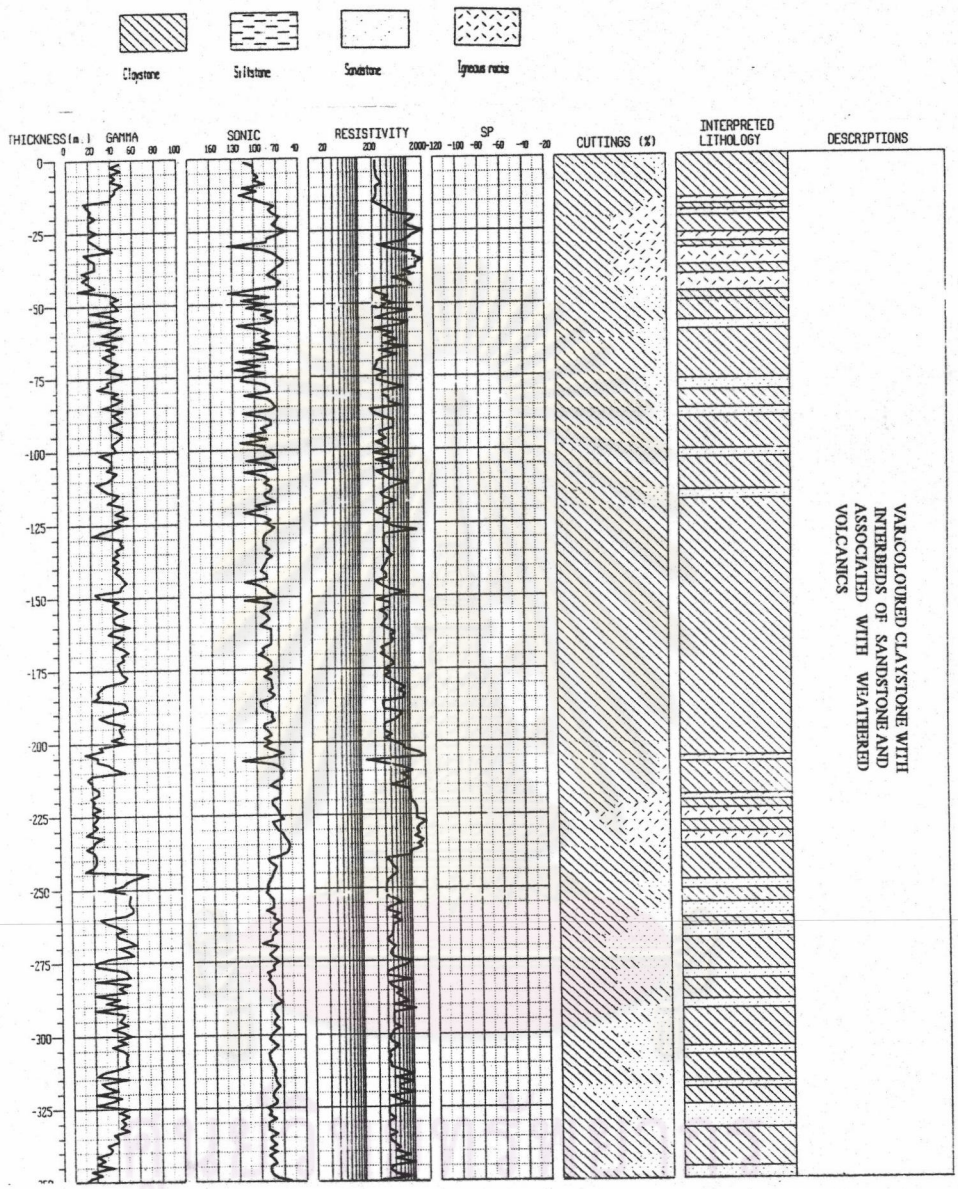

Figure 3.1 Lithological and geophysical characteristics of the WB-1 Formation.

- Lithology

The WB-1 Formation consists of varicoloured claystone interbedded with sandstone. It includes weathered fine-grained volcanics which intruded as sills or flows at the lower part of the formation. Thin limestone stringers were occasionally found in some parts of this formation, too. The lithology of the WB-1 Formation is not consistent through the area such as in the Bo Rang-1 well, located at the eastern part of the basin, it mainly consists of claystone with minor thin volcanics but without the presence of sandstone.

Lithologically, claystone is characterized by varicolour, varies in the shades of red, brown, grey, green, blue, purple. It is soft to firm, hard in parts, blocky, occasional slightly silty, non calcareous to slightly calcareous. Sandstone is characterized by clear, translucent, greenish grey to dark green, reddish brown, very fine- to medium- grained, occasionally coarse-grained, sub-angular to rounded, moderately to well sorted. It contains abundant lithic rock fragments, loose quartz grains with argillaceous matrix and/or chloritic/kaolinitic matrix in parts. It is non calcareous and has poor visible porosity. Volcanics is characterized by weathered, medium to dark greenish grey and dark green, fine-grained, moderately hard, crystalline containing alkali feldspars, biotite, pyroxene and pyrite.

Petrographic study of the igneous samples from the Si Thep-1 well suggests that these rocks are likely to have an volcanic affinity from the occurrence of feldspar microlite. In addition, most of the phenocrysts observed in the thin section are less than 1 mm. These rocks are generally altered with the replacement of pyroxene or feldspars by chlorite and calcite include oxidation of opague minerals. The rocks are classified as an alkali intermediate volcanic flow based on the presence of pyroxene and the existence of alkali feldspars.

- Palynology

No detailed palynological analysis was given for this formation.

- Depositional Environment

The claystone here is interpreted as fluvial deposit in oxidised depositional environment. Sandstone generally exhibits fining-upwards profiles; the presence of sandstone interbeds in claystone suggest low-moderate energy environments. These oxidised sediments associated with volcanics probably represent a low-moderate energy in shallow water of alluvial-plain environment which occurring during the initial stage of basin development.

However, the WB-1 Formation in the Bo Rang-1 well which located in the deeper part of this basin was deposited in shallow lake condition.

WB-2 Formation

- General Consideration

The WB-2 Formation makes up significant large volume of the sedimentary sequence in the Wichian Buri sub-basin. It overlies conformably on the WB-1 Formation and unconformably underlies the WB-3 Formation. However, at the Khao Leng-1 well located at the northern part of the basin, the WB-2 Formation lies unconformably on the Permo-Triassic basement rock. This indicates that the basin had been developed from south to north. The formation has been found in the penetrated six wells.

Generally, the WB-2 Formation is characterized by a claystone dominant sequence. The upper boundary of the formation is defined by the unconformity. And the lower boundary is defined by the lithological change from dark claystone of this formation to varicoloured claystone of the underlying WB-1 Formation

The distribution of the WB-2 Formation is widespread throughout the basin with varying thickness. The total thickness of the formation from the unpublished well is about 1,260 metres. However, its thickness in general is thinned out toward the edge of the study area.

- Lithology

The WB-2 Formation comprises predominantly of claystone with some sandstone and siltstone interbeds. Its sand/clay ratio increases upwards. There are several igneous intrusive bodies within the WB-2 Formation. The igneous intrusive rocks have been penetrated in every wells except the Si Thep-1 well. These sills are well regonized by geophysical logs and can be divided into two groups on the basis of log character. The first group is characterized by a very low GR response, and another group by a higher GR response.

Based on lithology and log characters, the WB-2 Formation can be divided into 3 members; WB-2A, WB-2B, and WB-2C Members in ascending order. Each member appears to have significant lithological characters.

1. <u>WB-2A Member</u>

The WB-2A Member is the lowermost lithostratigraphic unit of the WB-2 Formation. It appears to overlie conformably on the WB-1 Formation and is

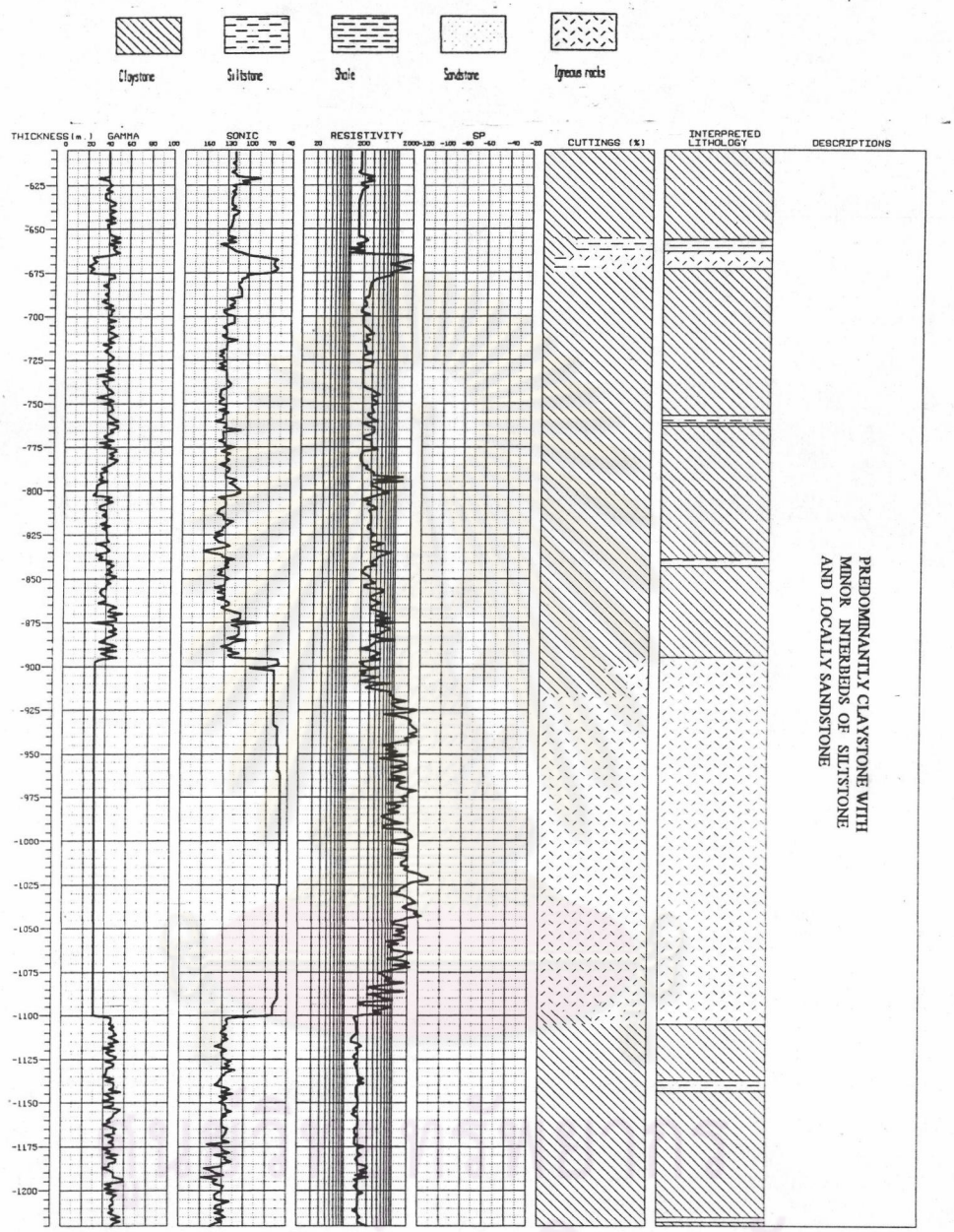

Figure 3.2 Lithological and geophysical characteristics of the WB-2A Member.

conformably overlain by the WB-2B Member. The member consists predominantly of claystone with rare interbeds of siltstone and locally fine-grained sandstone. Its upper boundary is placed at the base of the lowermost sand package of the WB-2B Member. Its lower boundary is defined by distinctive lithological change to varicoloured claystone. Besides, the signature from geophysical log of the WB-2A Member is rather unique. Due to the fact that the Wichian Buri-2 and Wichian Buri-3 wells reached total depth within the upper section of the WB-2A Member, therefore the characteric of the member from both wells is accordingly limited.

Most of the sedimentary sequence of WB-2A Member is composed of dark, organic-rich claystone, containing a few siltstone layers. The sequence of this member in the northern part of the area is influenced by some fine-grained argillaceous sandstone as shown in sidewall cores of the Khao Leng-1 well. However, sandstone beds make up a few percent of the total thickness. The sequence has been intruded by several thick igneous intrusive bodies and much of the original sedimentary fabric has been altered or destroyed adjacent to these sills. Igneous sills encountered in the WB-2A Member show both the low and higher GR response. The thickness of igneous intrusives occurring the WB-2A Member varies from 10 m. in the unpublished well to 50 m. in the Khao Leng-1 well, and especially in the Bo Rang-1 well, is about 500m.

Lithologically, claystone is characterized by brown, brownish grey to dark grey and black. It is firm, moderately calcareous and high carbonaceous in places. Towards the igneous intrusive, it becomes dark, hard, fissile, baked and tends to be the shale. Siltstone is characterized by light grey to brownish grey or greyish brown, firm to moderately hard, fissile and calcareous. It contains dark mineral speckles and abundant carbonaceous in places. Igneous intrusion is diorite and characterized by dark grey to greenish black, crystalline, with interlocking plagioclase feldspar, quartz,

associated with mafic minerals includes pyroxene, amphibole, biotite, trace pyrite and calcite.

In thin section, the dominant type of igneous samples collected from the Bo Rang-1 well, identified here is lathwork textured rocks. It consists of interlocking crystal of plagioclase laths. Majority of the grain sizs observed are generally <1.00 mm.

2. WB-2B Member

The WB-2B Member overlies conformably on the WB-2A Member and underlies conformably the WB-2C Member. It is also a claystone dominant sequence with coarsening-upward character. The top limit of the WB-2B Member is defined by a change in lithology and log character. And the base limit of the WB-2B Member is easily distinguished by the abrupt lithological change from the lowermost sandstone zone of the WB-2B Member to claystone of the WB-2A Member.

The lithology of the WB-2B Member is characterized by mainly of claystone with interbedded sandstone and siltstone. In the Bo Rang-1 and Khao Leng-1 wells, igneous intrusive rocks were penetrated within this member. The sandstone units in the WB-2B Member, generally exhibit coarsening upward profiles which are relatively thin (1-2 m). In addition, the ripple marks through small scale cross-bedding are the dominant physical sedimentary structures of the sandstone unit. In the upper part of the member the claystone appears to contain more silt content and significantly greater proportion of interbedded sandstone than in the lower part. From log character, the claystone in the upper part exhibits generally cylindrical profile. Besides, in the upper part of the member is slightly calcareous cemented, and carbonaceous as compared with the lower part. It is noted that, only minor sandstone containing a significantly

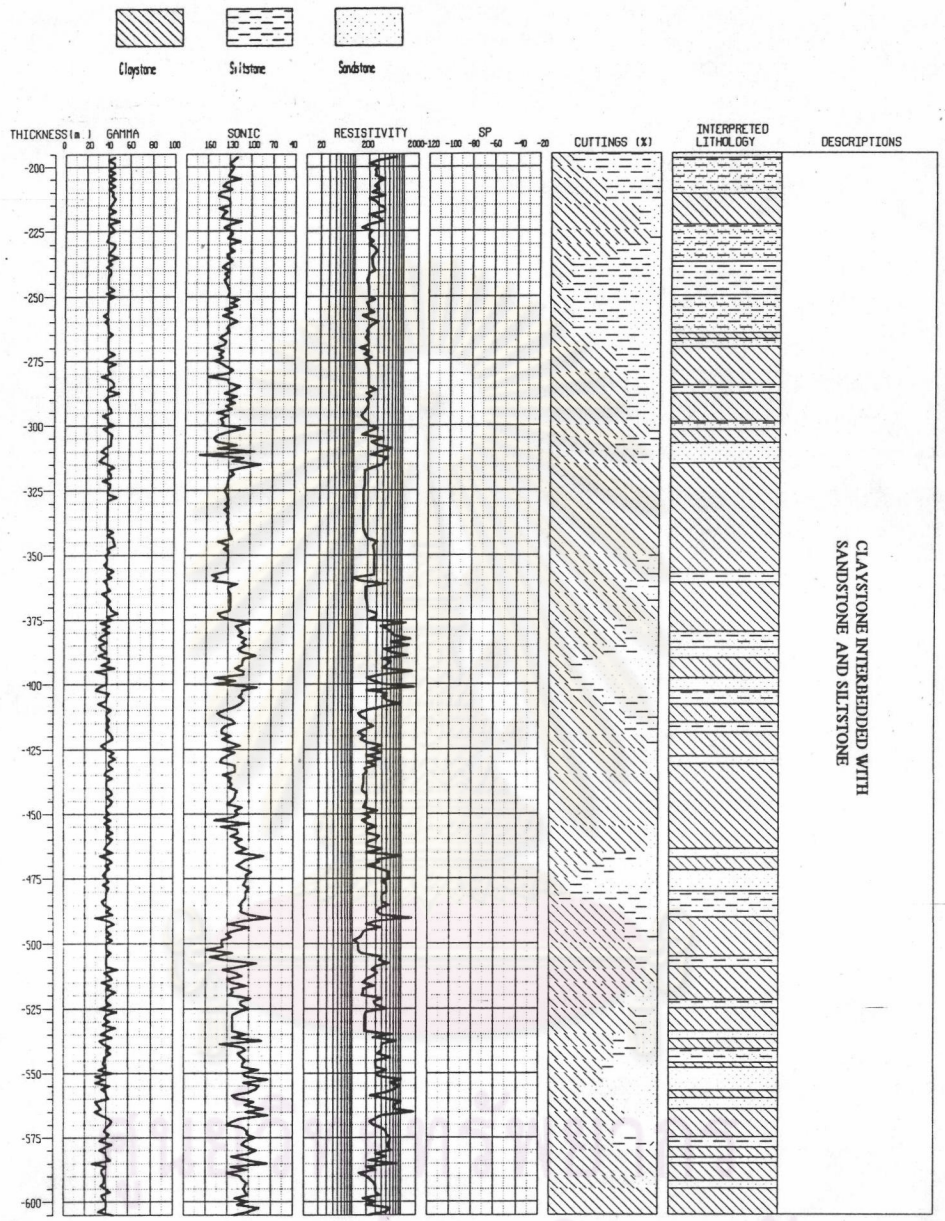

Figure 3.3 Lithological and geophysical characteristics of the WB-2B Member.

greater proportion of claystone were found in the Bo Rang-1 well.

Lithologically, claystone is characterized by light grey and light bluish grey to dark grey. It is firm to occasionally hard, sticky, blocky to slightly fissile, calcareous, silty in parts and carbonaceous to very carbonaceous in places. Sandstone is characterized by clear to white and light grey, very fine- to medium- grained, occasionally coarse-grained, subangular to rounded, poorly to moderately sorted, containing argillaceous, and loose. It contains carbonaceous speckles in parts, current ripples, small scale cross-bedding bioturbations, and has poor to fair visible porosity. Siltstone is characterized by greyish brown to brown, soft to moderately hard, blocky, carbonaceous to highly carbonaceous, and calcareous. It occasionally grades to very fine- grained argillaceous sandstone in parts.

Petrographic analyses carried out on sidewall cores from sandstone within this member are all consistent. They are classified as predominantly sublitharenites, with occasional feldsparthic litharenite. It contains predominantly of quartz with subordinate rock fragments and up to 10 % clay minerals, and generally calcite cemented.

3. WB-2C Member

The WB-2C Member is the uppermost lithostratigraphic unit of the WB-2 Formation. This member represents a transition unit of the WB-2 Formation before changes to the sandstone dominant sequence of the overlying WB-3 Formation. The WB-2C Member comprises of a mixture of lithologies, characterized by interbedded claystone, sandstone, and siltstone with minor coal. Upsection, the claystone content of the member decreases as sandstone content concomitantly increases. Sandstone in the WB-2C Member exhibits cylindrical profiles and becomes coarser - grained toward

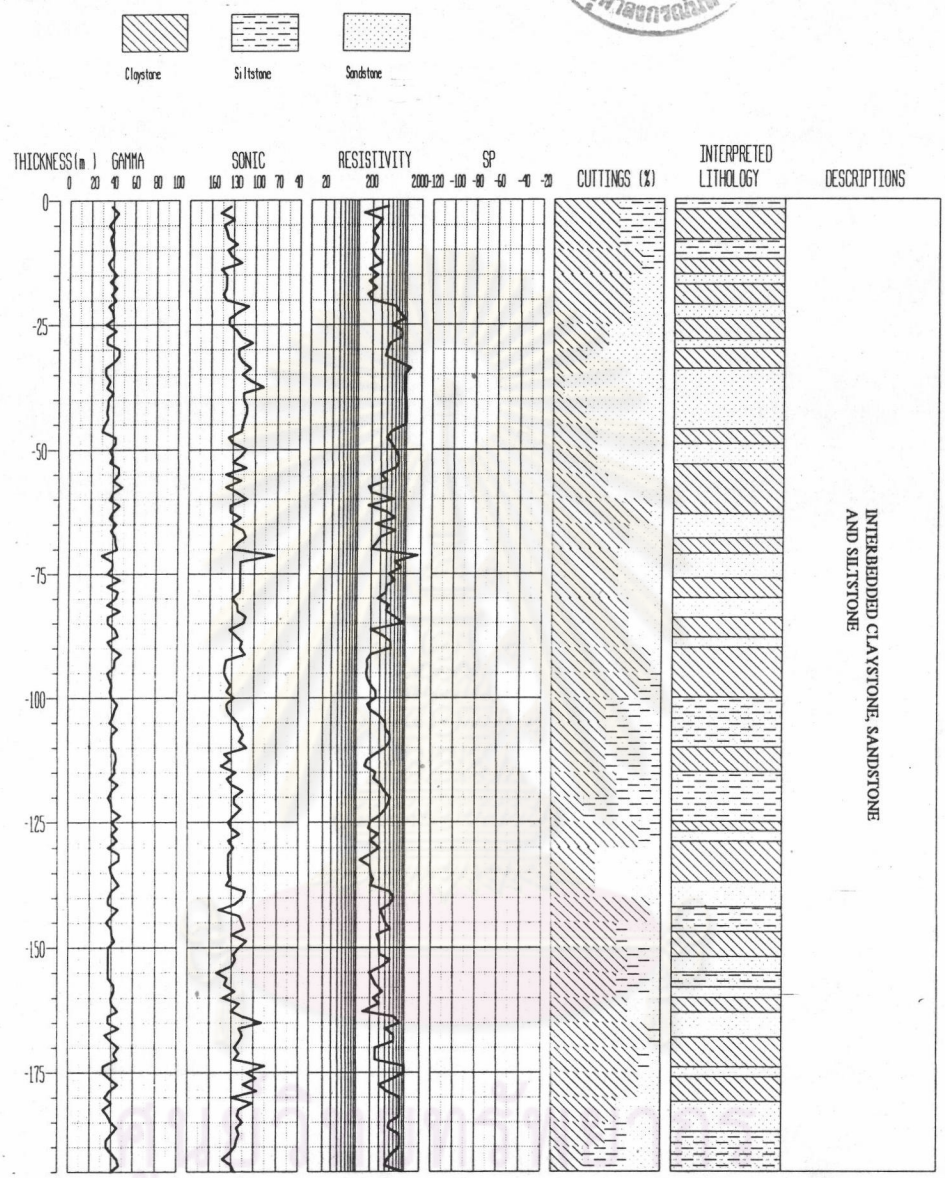

Figure 3.4 Lithological and geophysical characteristics of the WB-2C Member.

the upper part of the member. Its upper boundary is defined by the tuffaceous unit at the base of the overlying WB-3 Formation. The lower boundary is defined by a lithological change to predominantly claystone of the WB-2B Member.

Lithologically, claystone is characterized by light to dark grey, greenish grey, bluish grey and brown. It is soft to firm, silty, laminated, common to abundant carbonaceous in parts and calcareous in parts. The claystone becomes darker and more fissile when it is carbonaceous. Sandstone is characterized by white to light grey, very fine- to coarse- grained, but predominantly fine- to medium- grained, subangular to subrounded, moderately sorted, containing trace to abundant argillaceous matrix, and trace to abundant lithic fragments. It is calcareous and has poor to fair visible porosity. Siltstone is characterized by brownish grey to brown, firm to slightly hard, and commonly carbonaceous.

In thin section, samples of sandstone collected from the Wichian Buri-2 well, at the depth of 647 m. are feldspathic litharenite. The sandstone is fine- to coarse-grained, poorly to moderately sorted, subrounded to subangular, very good porosity (18%), and comprising of quartz, feldspars, and some rock fragments.

- Palynology

In the lower part of the WB-2 Formation, its palynomorph assemblage is characterized by poor to good recovery, moderately preservated and low diversity. Kerogen recovery comprises of abundant amorphous organic material. Assemblages are dominated by fresh water algae, particularly *Pediastrum sp.* The miospores dominated by undifferentiated tricolporate pollen were rare to common in this part.

In the upper part, its palynomorph recovery varies from poor to good. Preservation is moderate to good within the upper part of the member, becoming moderate lower down, and diversity is moderate. A distinct kerogen change is marked by an influx of common to abundant vitrinite macerals associated with decreasing in amorphous organic material. Palynomorph assemblage is characterized by a dominant undifferentiated tricolporate pollen group in association with relatively common *Pentace*, and relatively low but consistent frequencies of *Cephalomappa, Laevigatosporite* and *Botryococcus sp.*

- Depositional Environment

From the fine-grained sediments and lack of current-generated structures, the WB-2A Member is interpreted as having been deposited from suspension in a low energy environment. The predominance of dark claystone, reflecting high organic content and representing conditions of rarely sandstone deposition, indicates a lacustrine environment under reducing condition.

The palynological data also supports the depositional environment of this nearly homogenous claystone sequence. Based on the abundance of amorphous organic material and fresh water algae (*Pediastrum sp.*) which indicate lacustrine sediments. Besides, the low miospore recovery which may be related to an open lacustrine setting, nevertheless judging from the rarity of sandstone and lack of vitrinite macerals, suggests that the fluvial system seems to be minor.

For the WB-2B Member, the lithological association of sandstone and siltstone interbedded with claystone in a predominantly claystone sequence indicates fluvial influence within a lacustrine environment. The sudden appearance of sandstones at the lower contact of the WB-2B Member may indicate as fluvial deposits of high

current. The general coarsening-upward nature of the sandstones and physical sedimentary structures, suggest that the sandstones were deposited in a delta system. In general, these coarsening-upward sequences within the claystone dominant sequence were repeated vertically indicating several short-life periods of delta progradation in the lake. The deltaic-lacustrine environment of deposition is proposed for the WB-2B Member.

In addition, the palynological data also confirm a supradital predominant lacustrine with fluvial influence condition for the WB-2B Member. For example, the evidence of common to abundant amorphous organic material throughout much of the interval, and associated with relatively common *Pediastrum sp.*, indicate a possible dominant lacustrine environment. Whilst the incoming of vitrinite macerals, *Pentace sp.*, as well as on the basis of lithological considerations, it may be interpreted as the indication of variable fluvial influence. Taking these factors into account it is likely that the paleoenvironment was marginal lacustrine.

The sedimentation of the WB-2C Member representing a period of high clastic sediment input results in a general increase in sandstone units, and the intervals of claystone are thinner. Sandstone in the member exhibits cylindrical profiles suggesting a fluvial origin. When combined with the presence of abundant lithic fragments in sandstone, abundant carbonaceous material including coal seams in the claystone, this suggests its deposition occurring in a shallow lake with increasing influence of alluvial processes. Therefore, a fluvio-lacustrine condition is proposed for the depositional environment of this member.

Based upon palynomorph and kerogen observations, a fluvial/lacustrine environment is considered for the deposition of the WB-2C Member, too. An increase of vitrinite macerals, *Pentace sp.*, and the presence of *Laevigatosporites sp.* indicate

increasing fluvial influence. To a lesser extent, the common occurrence of amorphous organic material and relative low algae frequencies still suggest lacustrine environment. It should be noted that in the Wichian Buri-3 well, claystone at approximately 570 m. deep is light brown and poor palynomorph recovery. When it is combined with the presence of common sandstone, would possibly indicate the disappearence of dominantly reducing condition, and suggest a transition to oxidizing condition. According to the appearence of the volcanic tuffs at 520 m. deep, at its upper contact with the overlying WB-3 Formation suggesting that an possible unconformity may be inferred at this depth.

WB-3 Formation

The WB-3 Formation overlies unconformably on the WB-2 Formation and unconformably underlies the WB-4 Formation. The formation represents a sandstone dominant sequence. The lithology of the WB-3 Formation is inconsistent throughout the basin. In contrast to other wells, the lithology of this formation penetrated in the Bo Rang-1 well is typical claystone sequence. The upper unconformity is defined in accordance with the upper marker in seismic stratigraphic correlation, and is used as the upper boundary of the WB-3 Formation throughout the basin. The WB-3 Formation was penetrated in all six wells.

The WB-3 Formation has an approximate thickness of 300 m. at the central part of the basin. However, a little of this formation was founded at the Khao Leng-1 well.

- Lithology

Generally, the WB-3 Formation consists mainly of sandstone interbedded with

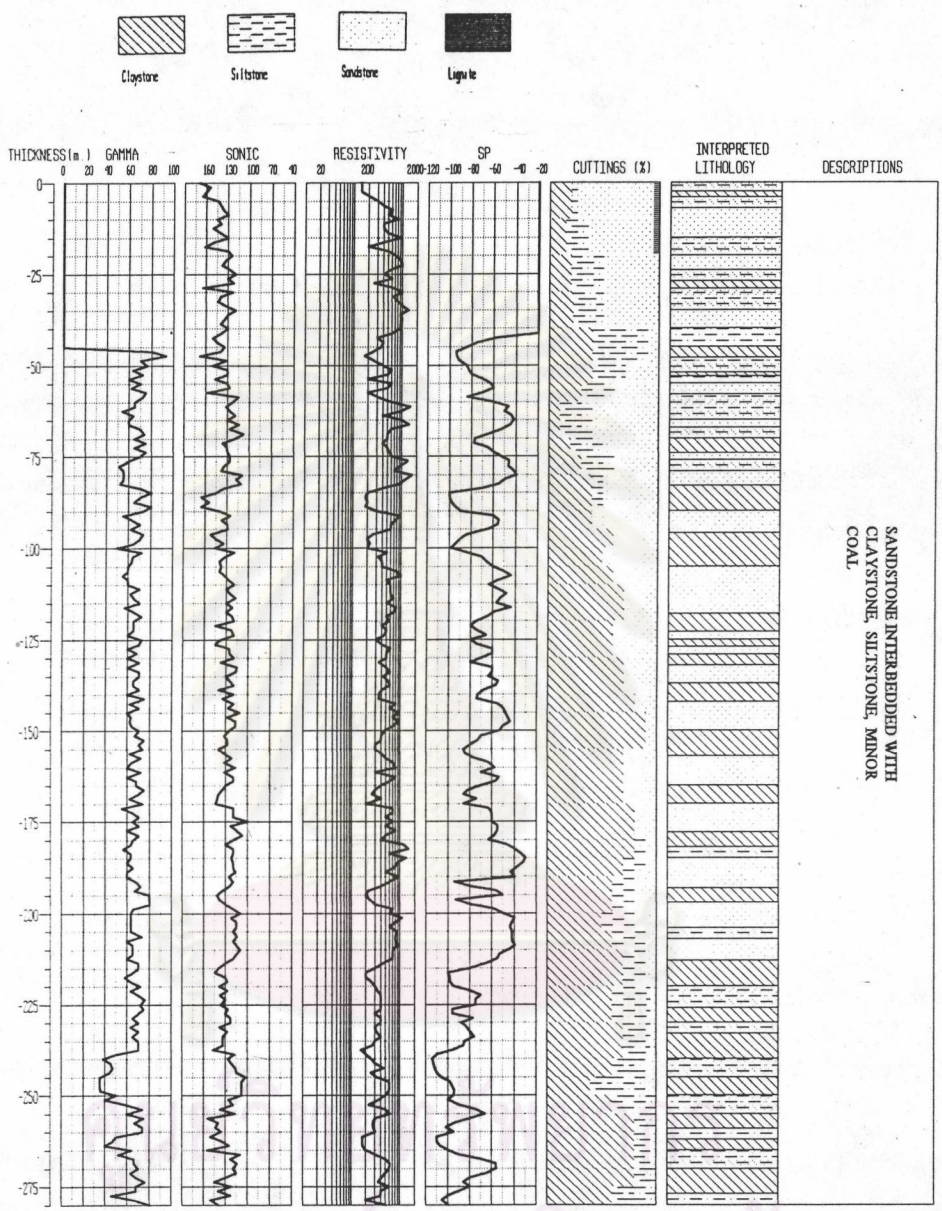

Figure 3.5 Lithological and geophysical characteristics of the WB-3 Formation.

claystone, siltstone and minor coal. The colour of the sedimentary sequence is dominantly brown. From electric log character, the sandstone exbihits both fining-upwards and coarsening-upwards profiles. The lower part of the formation is gradational with sandstone contents decrease downwardly to a clay-rich sequence. In this formation, the claystone often is silty in places and the siltstone often grades to sandstone. Traces of limestones were observed. Note that the WB-3 Formation penetrated in the Bo Rang-1 well still represents the claystone dominant sequence. The top of the formation is placed at the unconformity with a change of lithology from sandstone dominant sequence of this formation to claystone dominant sequence of the overlying WB-4 Formation, which is clearly recognized by log character change. The base of the formation is defined by a series of altered basaltic tuff, with a characteristic low GR response.

Lithologically, sandstone is characterized by clear, light brown to brown and occasionally light to dark grey, fine- to coarse- grained, and become finer grained grading to the base, subangular to subrounded, poorly to moderately sorted, loose, containing trace to abundant lithic fragments and argillaceous in parts. It is calcareous, occasional carbonaceous pecks and has poor to fair visible porosity. Claystone is characterized by light brown to brown and grey to dark grey colours. It is soft to firm, sticky, blocky to subfissile, common to abundant carbonaceous with occasional coaly inclusion, calcareous, common silt to fine sand. Siltstone is characterized by brown to brownish grey, grey to greenish colours, soft, calcareous, sandy, carbonaceous in parts.

Based on the petrographic analysis of sandstone at depth 530.9 m. from the Wichian Buri-2 well indicating that it is litharenite. It is medium-grained, poorly to moderately sorted, comprising predominantly of quartz (42%) with subordinate amount of rock fragments (22%) and feldspar (6%), slightly calcareous and siliceous

cement, good visible porosity (18%). For sample at depth 607.6 m. indicates that it is altered basaltic tuff. It contains altered minerals of mafic origin.

- Palynology

Palynomorph assemblages from this formation are characterized by variable poor to good recovery, moderate preservation, and low to moderate diversity. Kerogen residuals generally comprise of common to abundant vitrinite macerals with subordinate amount of amorphous organic material remains in places. The most abundant palynomorphs are the undifferentiated tricolpate / tricolporate and Gramineae (grass) pollen. *Pentace sp.* becomes abundant in its distribution but occurrence of *Pediastrum. sp.* is rare. There is a marked kerogen and palynological change at the upper part of the WB-3 Formation indicate fluvial depositional environment. Coal seams in this formation are considered to have a fluvial accumulation origin.

- Depositional Environment

In contrast to the claystone dominant sequence of the lower strata, the lithology within the WB-3 Formation is a sandstone dominant sequence. Sandstone exhibits both fining-upward and coarsening-upward sequences and variable grain sizes. Sedimentation of the WB-3 Formation occurrenced in a fluvial depositional environment. Coal seams in this formation are considered to have a fluvial origin, too.

The palynological data also indicate the predominantly fluvial environment in accordance with the common to abundance of vitrinite macerals, the relatively abundant *Pentace sp.*, and the reduction of amorphous organic material. Besides, the abundance of Gramineae (grass) pollen indicate a relatively alluvial plain vegetation proximal to the site of deposition. Many of the undifferentiated tricolpate/tricolporate

pollen were interpreted to be associated with tropical fresh water swamp forest. For the absence of significant fresh water algae *Pediastrum sp.* may be used to distinguish the WB-3 Formation from the underlying WB-2 Formation. There is a marked palynological and palaeoenvironment change at the upper part of the formation, this probable represents the onset of a relative cooler climatic trend.

WB-4 Formation

- General Consideration

The WB-4 Formation is the uppermost lithostratigraphic unit of Tertiary sequence within the Wichian Buri sub-basin. The formation is bounded by unconformities. It overlies unconformably on the WB-3 Formation and unconformably underlies the Quaternary deposits. The lithology of this formation is very consistent throughout the basin. The WB-4 Formation was penetrated in the unpublished, Wichian Buri-2, Wichian Buri-3 and Si Thep-1 wells but is absent at the Bo Rang-1 and the Khao Leng-1 wells.

The total thickness of the WB-4 Formation is 300 m. It has a tendency to be thickening in the southern part of the study area.

- Lithology

The WB-4 Formation is a predominantly fine-grained sequence. It comprised mainly of grey claystone with minor interbeds of sandstone and locally siltstone. Downward, sandstones become increase in numbers and their thickness. The top of the WB-4 Formation is recognized on the basis of a change in electric log response and the base coincides with a lithological change from a claystone dominant sequence to a

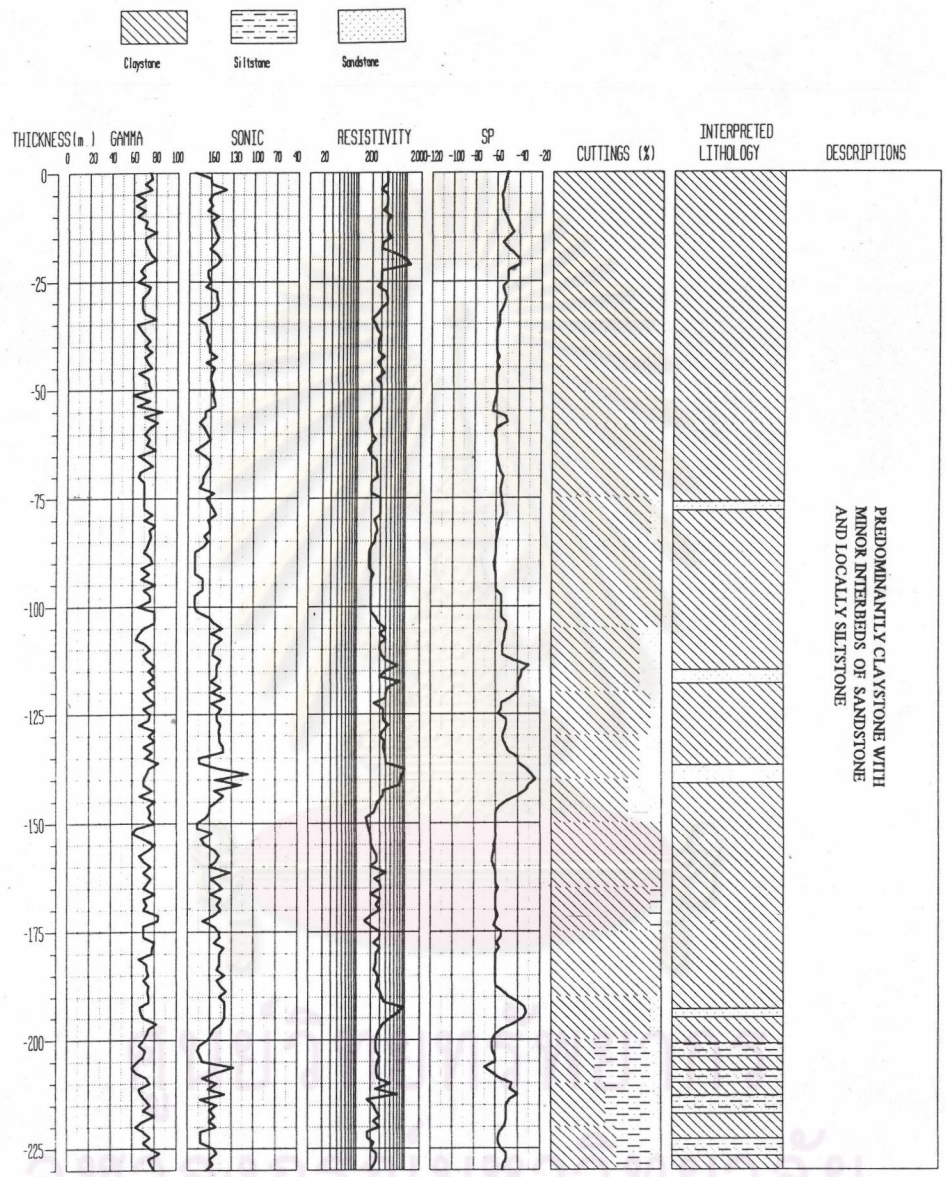

Figure 3.6 Lithological and geophysical characteristics of the WB-4 Formation.

sandstone dominant sequence.

The lithostratigraphy of the formation can be separated into 2 parts, the lower and the upper parts. In the lower part, It comprises mainly of silty claystone or claystone interbedded with sandstone and locally siltstone. In this part, the sandstone interbeds are more than the upper part. This interval also contains thin coal bands which were found in the Wichian Buri-2 and the Si Thep-1. The boundary between the lower and upper parts is recognized by the presence of silty claystone. The lithologies of the WB-4 Formation in the upper part comprises predominantly of claystone interbedded with minor thin sandstone layers. Claystone becomes darker in clour whilst it is grey to light grey in the lower part. Number and thickness of sandstone layers of this part are less than the lower part.

Lithologically, claystone is characterized by light grey to grey, greenish grey, and occasionally greyish brown colours. It is soft to firm, blocky, sticky, calcareous, micaceous laminae in parts, and trace to common silty in parts. Sandstone is characterized by clear, translucent, fine- to medium- grained, light grey to greenish grey and become brown toward the base, subangular to subrounded, well to moderately sorted, containing common argillaceous matrix, and calcareous in parts. Siltstone is characterized by brown and grey to dark grey, soft, friable, trace sand, calcareous, and carbonaceous in parts.

- Palynology

The Palynomorph assemblage is characterized by good palynomorph recovery and high diversity. Kerogen recovery comprises of common to abundant amorphous organic material.

The palynomorph assemblage within the WB-4 Formation is characterized by common to abundant frequencies of fresh water algae *Botryococcus sp.*, Gramineae (grass) pollen and consistent frequencies of temperate/montane taxa. The abundance of Gramineae pollen decreases markedly beneath the contact with the underlying WB-3 Formation. Towards the base there is an increasing of undifferentiated tricopate and tricolporate pollen which are associated with tropical freshwater swamp forest.

- Depositional Environment

Based upon the lithological characteristics of mainly fine-grained sediments with rarity of medium-grained clastics of the WB-4 Formation, indicates a predominantly lacustrine environment of deposition. From sidewall cores, the claystone is very laminated in parts suggesting a low to moderate energy environment. In the sedimentary sequence of the formation, it appears to be more influence of medium-grained clastics gradually passing downward into silty claystone associated with sandstone beds. Besides, the upward colour change from light to dark grey of claystone indicating that sedimentation rates were at first high, but decreased with time. These suggested this unit deposited under relatively low energy environment with nearby higher energy condition of the underlying WB-3 Formation. Therefore, it is concluded that the predominantly lacustrine environment of deposition had been subjected to fluvial influence in the lower part of the formation.

The paleoenvironment is also supported by palynological data, particularly the occurrence of abundant amorphous organic material, associated with the abundant frequencies of *Botryococcus sp.* which like *Pediastrum sp.*, is often associated with lacustrine sediments. However, the relatively low frequencies of vitrinitic macerals, and the rarity of channel plant associations, it is likely that fluvial influence is relatively low.

With regards to paleoclimate, the occurrence of the pollen assemblage indicates a temperate climate. Towards the base there is an increase of tropical vegetation influence which suggests a gradual climatic change. This change was associated with a fall of sea level and also coincided with the tectonism in onshore of Thailand and the volcanism within the basin in Middle to Late Miocene.

In summary, the lithological and palynological characteristics of the sediments indicate a predominantly lacustrine depositional environment with little fluvial influence.

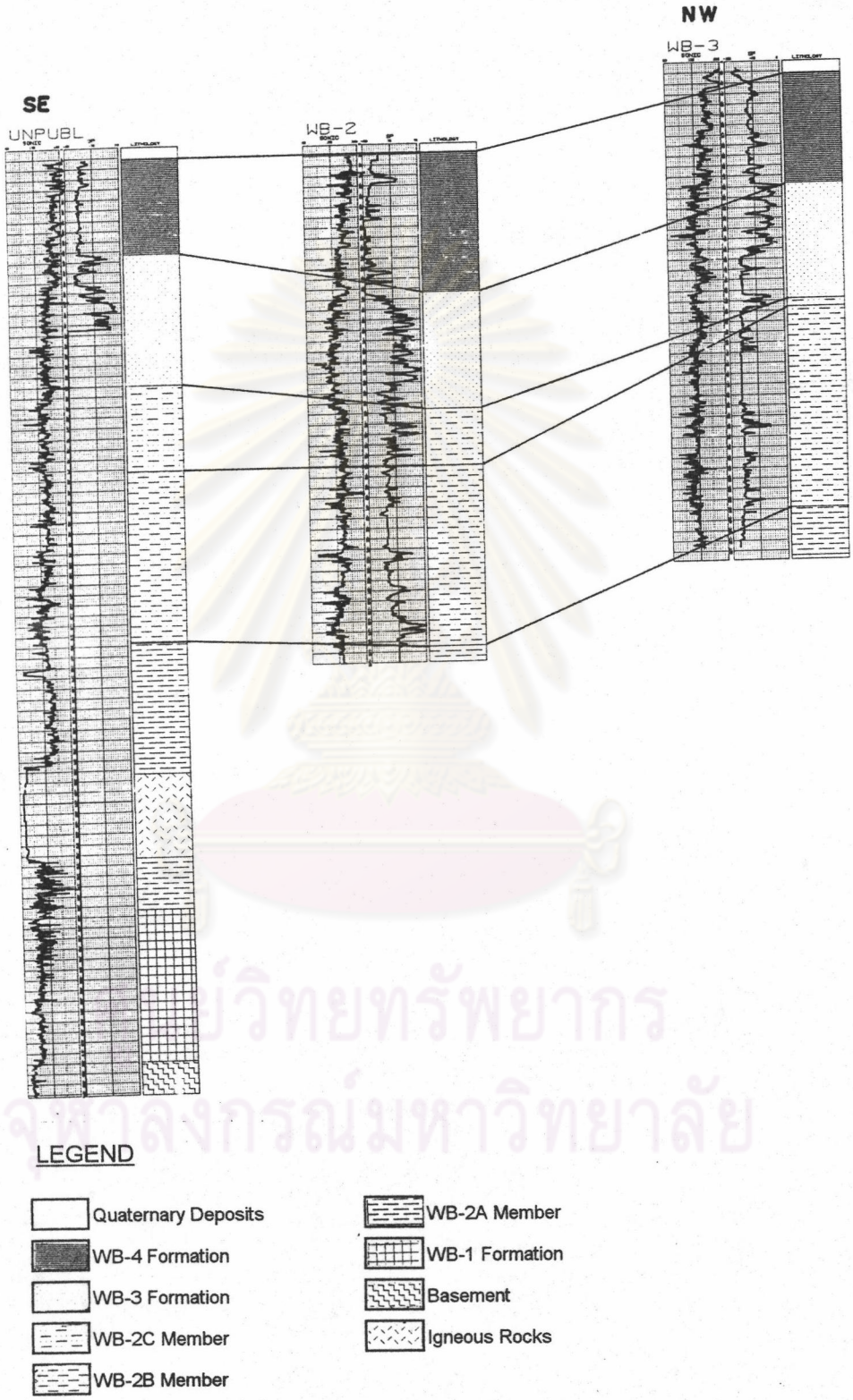

Figure 3.7 Stratigraphic correlation along a northwest-southeast profile across central area, the Wichian Buri sub-basin.

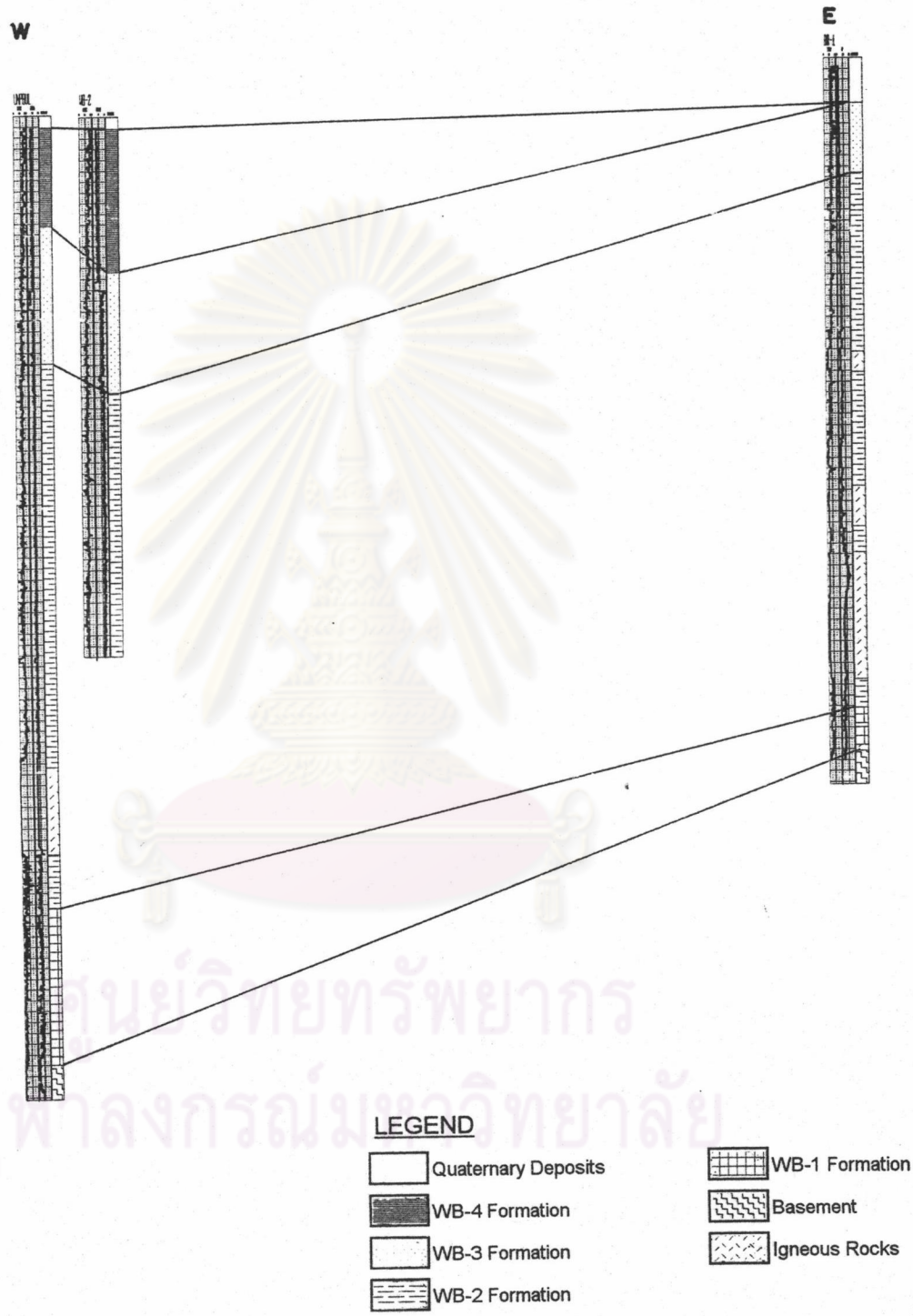

Figure 3.8 Stratigraphic correlation along an east-west profile across central area, the Wichian Buri sub-basin.

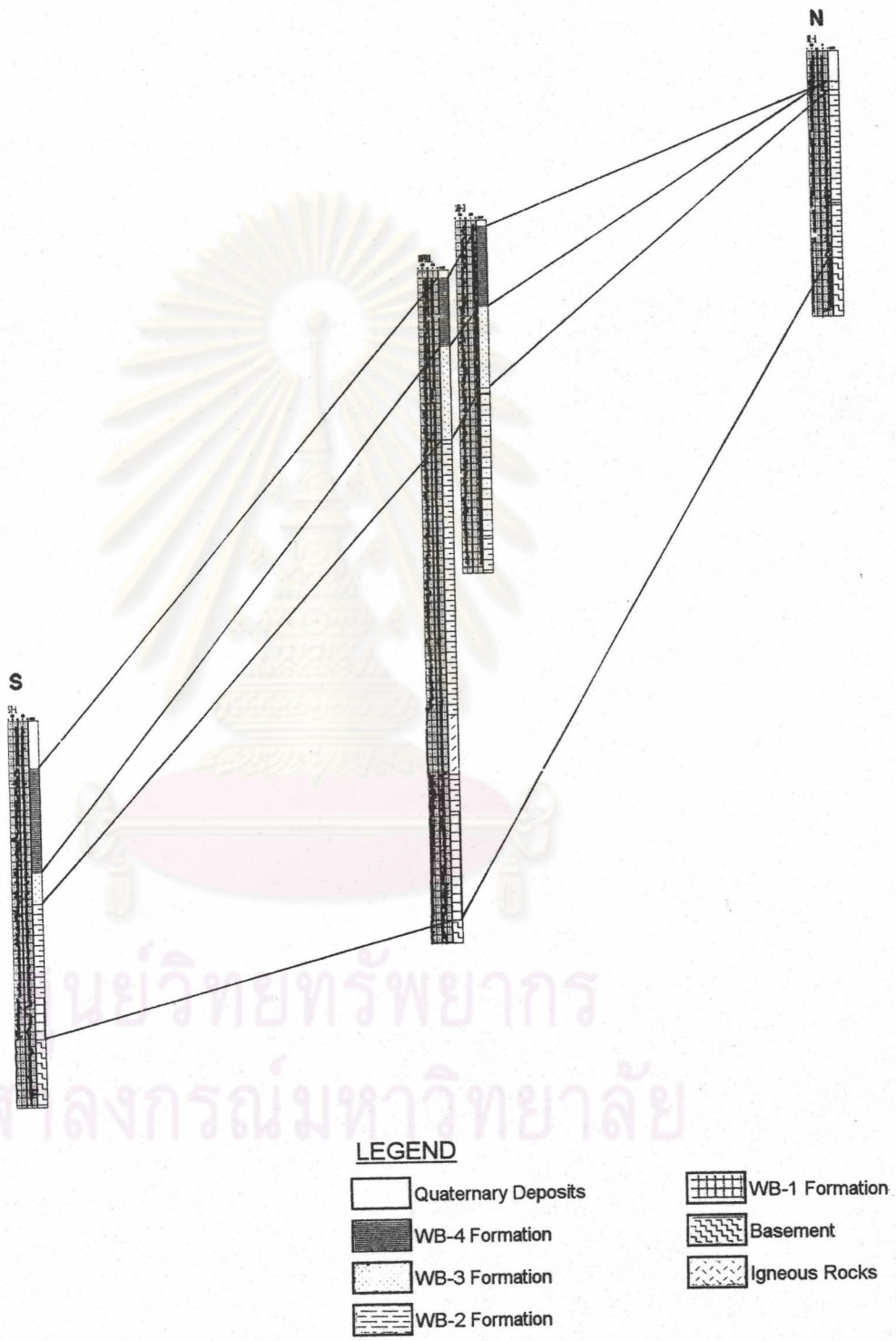

Figure 3.9 Stratigraphic correlation along a north-south profile across the Wichian Buri sub-basin.