CHAPTER IV

EVOLUTION OF SEDIMENTARY DEPOSITION

Tectonic Setting and Structural Style

1. Regional Tectonics

The development of Tertiary basins throughout Southeast Asia resulted from the northward progressive collision of the Indian Plate with the Eurasian Plate since Eocene to Recent. This Himalayan orogeny attributed extension of faults originally formed during various Paleozoic and Mesozoic orogenic events to the Late Oligocene reactivation (Tapponnier et al. 1986, Polachan and Sattayarak 1989, O'Leary and Hill 1989).

The onshore Tertiary basins aligned in a broad N-S trending belt that corresponds to an old suture zone between Indochina Craton in the east and Shan-Thai Craton in the west which has been suffered from several orogenic events since the Paleozoic. The common tectonic origin for these Tertiary basins has led to many similarities in age, basin fill, structural style and hydrocarbon habitats (Burri, 1989).

2. Structural Framework

The Wichian Buri sub-basin appears to lie near the intersection of two major strike-slip fault system. These faults are the NW-SE trending Mae Ping Fault Zone (MPFZ) and the NE-SW Uttaradit Fault Zone (UFZ). The MPFZ is the principal right-lateral strike-slip fault and the UFZ is the conjugate left-lateral strike-slip fault which is terminated by the MPFZ. The pre-Tertiary motion on the MPFZ and UFZ was sinitral and dextral in order. The sinistral strain of the MPFZ as shown by Bunopas (1981) that was active during Jurassic to Cretaceous, and ceased the moving in the Late Cretaceous, using the evidence of significant left-lateral offset of "various rocks in the western Thailand". Besides, Le dain et al. (1984) studied the mechanism of recent earthquake in S.E Asia and indicates that the MPFZ (Papun fault) is moving with right - lateral offset. Tapponnier et al. (1986) concluded that the MPFZ was re-activated and began to move with a right-lateral sense, reversing its pre-Tertiary left-lateral movement in the Late Cenozoic (Miocene) and also proposed that the UFZ which formed a conjugate set with the MPFZ, has move in an opposite direction to the MPFZ.

Polachan (1988) explained the change in moving direction of these faults and the development of Tertiary basins in Sundaland by using transtensional shear model, as the result of the collision of Indian Plate with Southeast Asia (Figure 4.1 & 4.2). The eastward movement and clockwise rotation of South China away from India, caused clockwise rotation of S.E. Asia, resulting in increasingly oblique subduction of the Indian Ocean Plate beneath the western edge of S.E. Asia. This led to the Mae Ping Fault and other NW-SE faults were re-activated and began to move with a right-lateral sense, reversing their pre-Tertiary left-lateral offsett in the Oligocene and still active up to the present. In this model, the Uttaradit Fault and other NE-SW trending strike-slip faults which form a conjugate pair to the NW-SE trending faults, therefore sinistral. Faults with a dominant N-S orientation were re-activated under extension and sedimentary basins, including the Wichian Buri sub-basin, were formed.

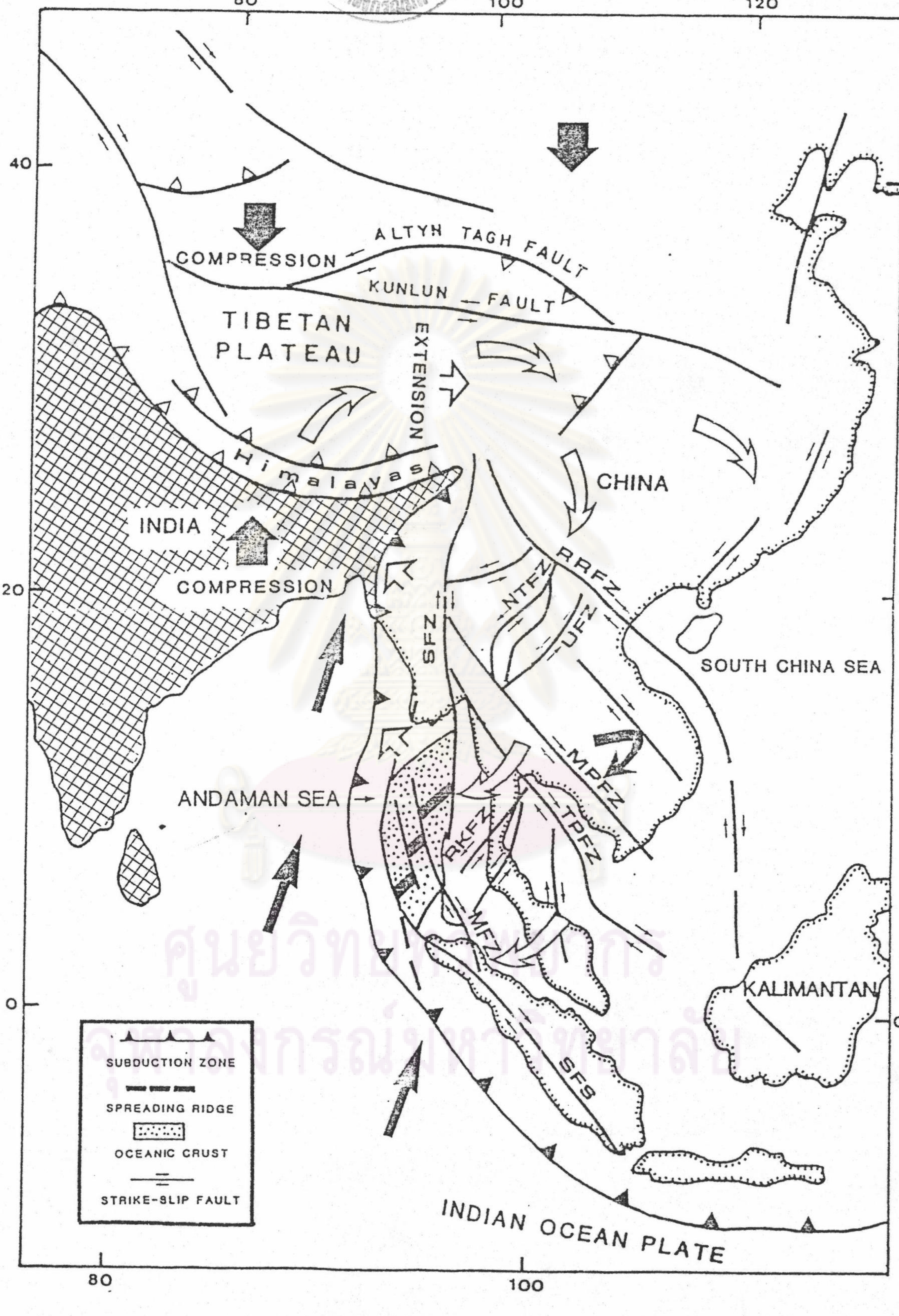


Figure 4.1 Tectonics map of S.E. Asia and South China (Polachan, 1988).

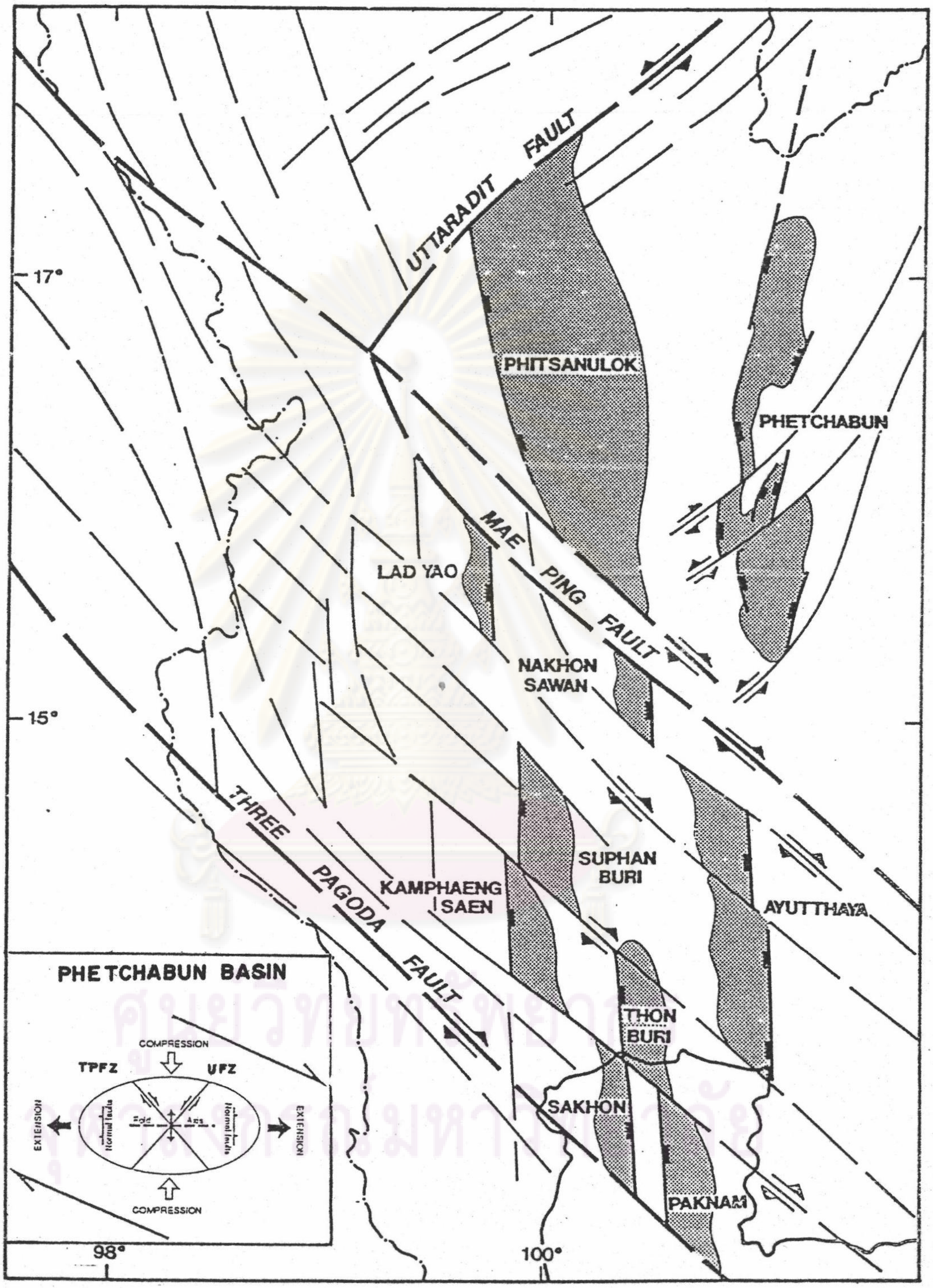


Figure 4.2 Structural map of the central of Thailand and the dextral transtensional shear model, Phetchabun Basin (modified from Polachan and Sattayarak, 1989).

3. Structural Style

3.1 Border Faults

In seismic cross-sections, the Wichian Buri sub-basin has half-garben geometry and are controlled by listric normal faults. The half garben structure of the basin is bounded on its eastern margin in the south of the basin by a westward dipping fault (subsequently referred to as the border-fault), but change to the west bounded half garben in the north where bounded by the eastward dipping fault, with the greastest accumulation of sediments on the downthrown block (Figure 4.3). The westward and eastward and dipping border faults trend "NNE-SSW and NNW-SSE" directions in order. These faults were active at the beginning of the development of the basin in the Oligocene. The throw of these faults is variable from 500 meters in the south to over one kilometers in the north of the basin. Consideration in the dip angles of the border faults through the northern, central, and southern parts of the Wichian Buri sub-basin, they appear variable.

The border faults controlled the basinal formation. Perhaps the best evidence of syndepositional faulting or growth faulting of the border faults was the increasing in thickness of Tertiary units toward the border faults. In addition to thinning away from the border fault in a transverse direction, time-correlative units thin out toward the lateral edges of the basin. If these variations in thickness of units are a agent for variations in basin subsidence, then subsidence was greastest near the center of the basin adjacent to the border fault and decreased away from this region in all directions.

3.2 Intrabasinal Faults

On the basis of seismic studies, the intrabasinal faults appear to

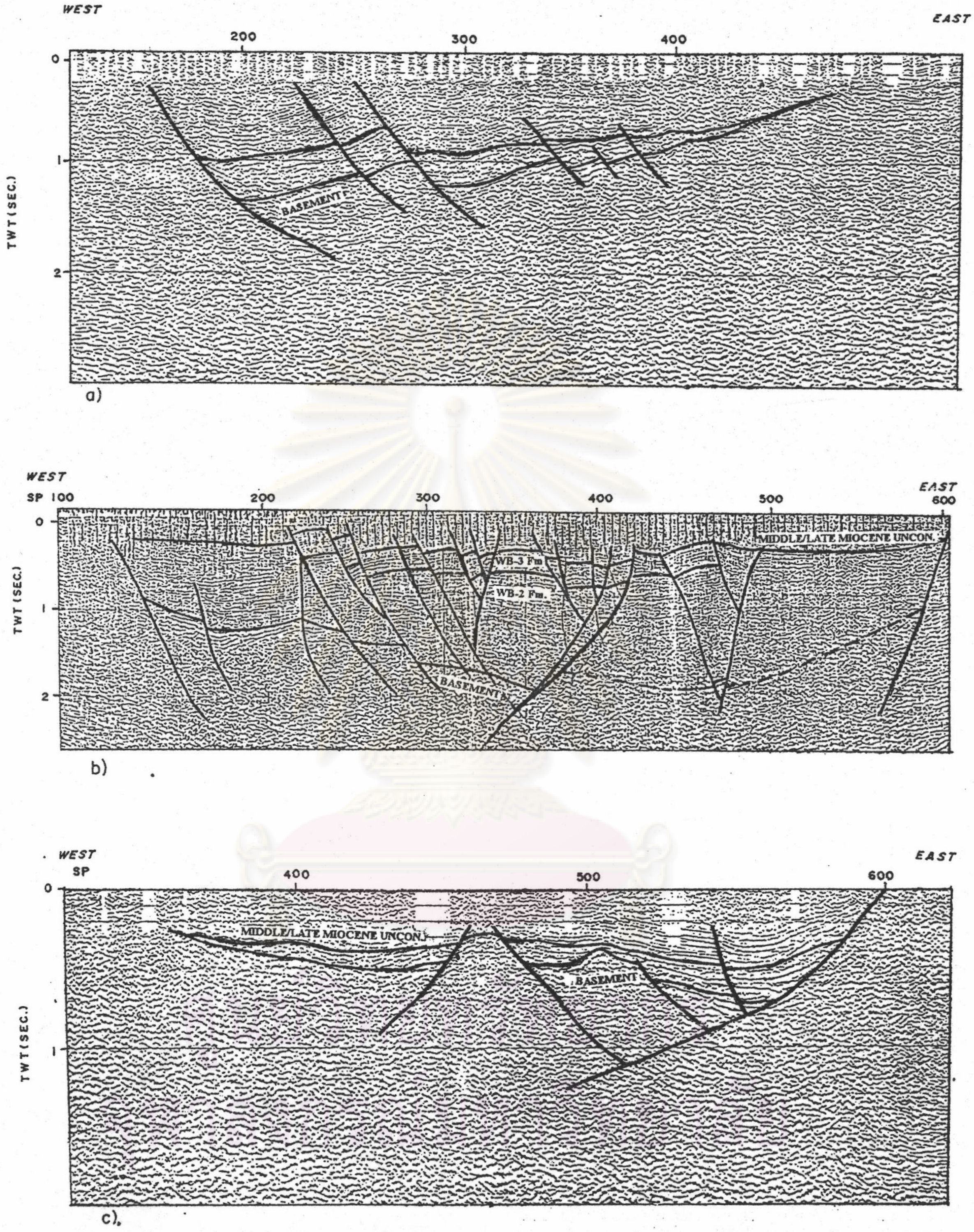


Figure 4.3 Interpreted seismic profiles of line SW1-88-11, SW1-88-09, and ST-88-103, showing the geometry of the Wichian Buri sub-basin

a) west bounded half-garben in the north

b) garben in the central

c) east bounded half-garben in the south.

postdate the deposition of Tertiary strata preserved in the hanging walls because none of preserved strata thickening toward the intrabasinal faults. These younger intrabasinal faults gave rise to a complex structure of synthetic and antithetic rotated block faulting. The density of the intrabasinal fault appears high in the central part of the basin, especially in the western side where contains numerous NNW-SSE trending fault blocks which throw down to the east and intersect with the main west dipping fault along the central axis of the basin (Figure 4.4a & b). For the eastern side of the basin is little deformed, with a few NNE-SSW trending fault blocks. Intrabasinal faults are considered to be extended down to the basement.

3.3 Structural Features

Three type of N-S structural style have been classified in the Wichian Buri sub-basin (Figure 4.4a, 4.5a & b). The Wichian Buri type classified as the N-S faults are located in the centre of the basin. The quality of seismic data is poor due to the surface basalts and seismic correlation is difficult due to the complex geology. However, the structure could be defined from the structural map. It is an anticline bounded by NNE-SSW faults. The Si Thep type is a central garben basement high, bounded by normal N-S faults to the west and east. Major recent fault movement is indicated by seismic and well data is considered likely to be the result of uplift of the basement horst underlying the Si Thep structure. For the Bo Rang type is a faulted dome structure fromed by the combination of N-S faulting and intrusions. The presence of this structure is considered likely to be the uplifted remnants of the basin.

Igneous Activities in the Wichian Buri Sub-basin

Igneous units are present throughout the stratigraphic sequence and are widespread within the Wichian Buri sub-basin. They include weathered fine- grained

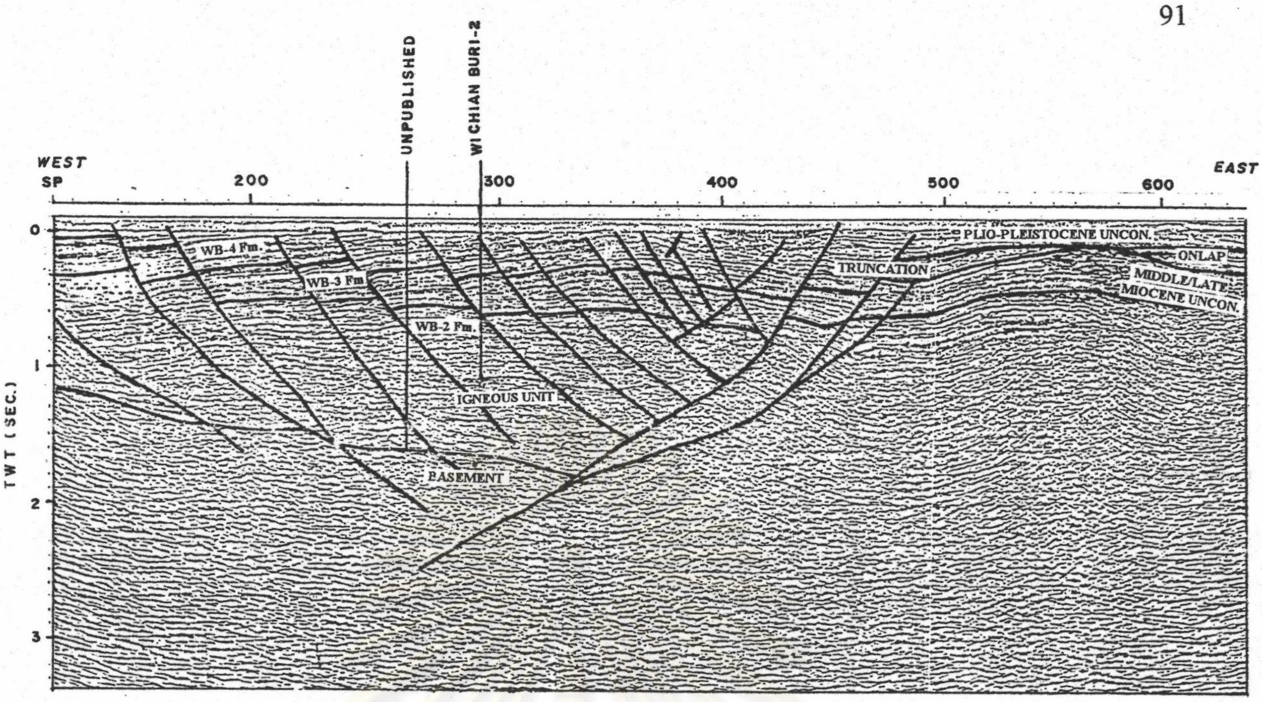


Figure 4.4a Interpreted seismic profile of line WB-89-05 across the unpublished and Wichian Buri-2 wells, showing rotated fault block and Wichian Buri type.

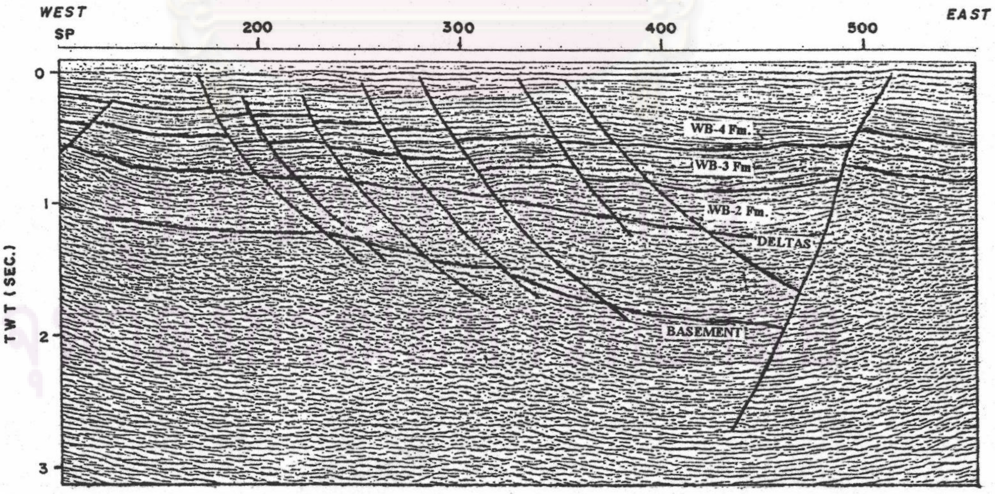


Figure 4.4b Interpreted seismic profile of line WB-89-03, showing the internal structure and prograding deltas within the basin.

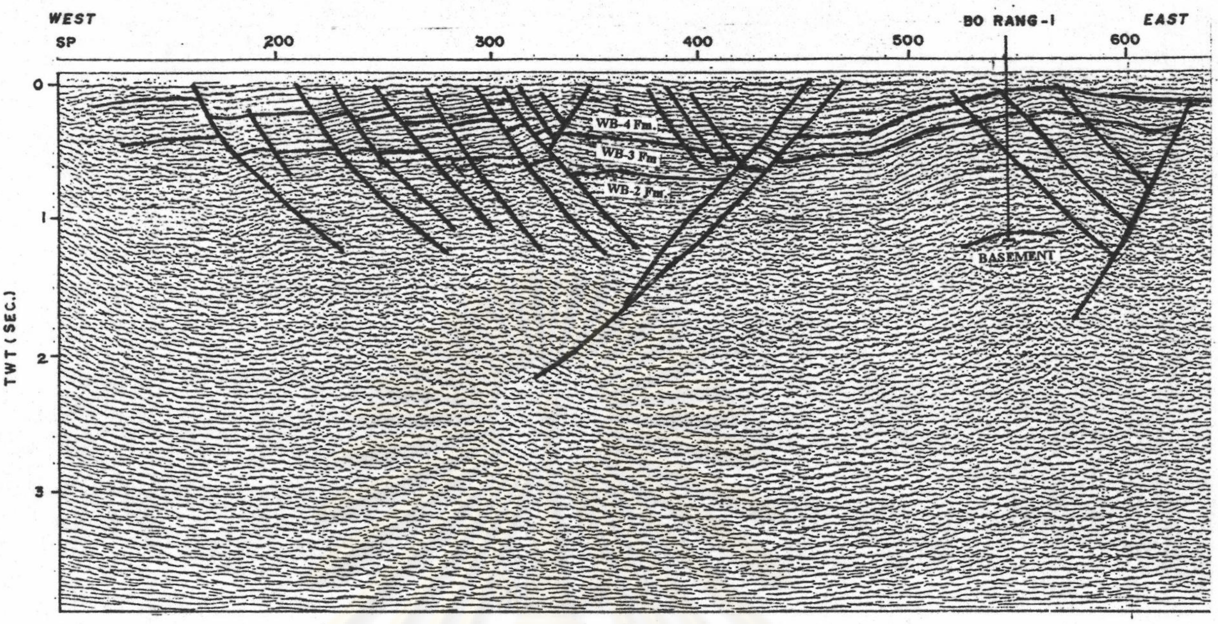


Figure 4.5a Interpreted seismic profile of line WB-89-07 across the Bo Rang-1 well, showing the presence of Bo Rang type.

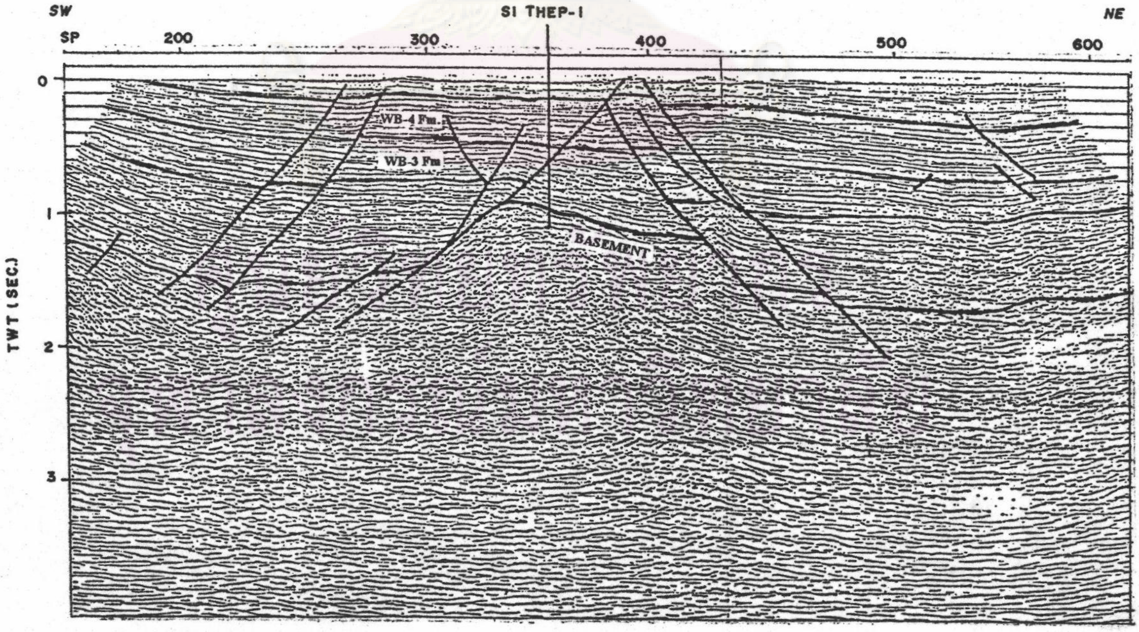
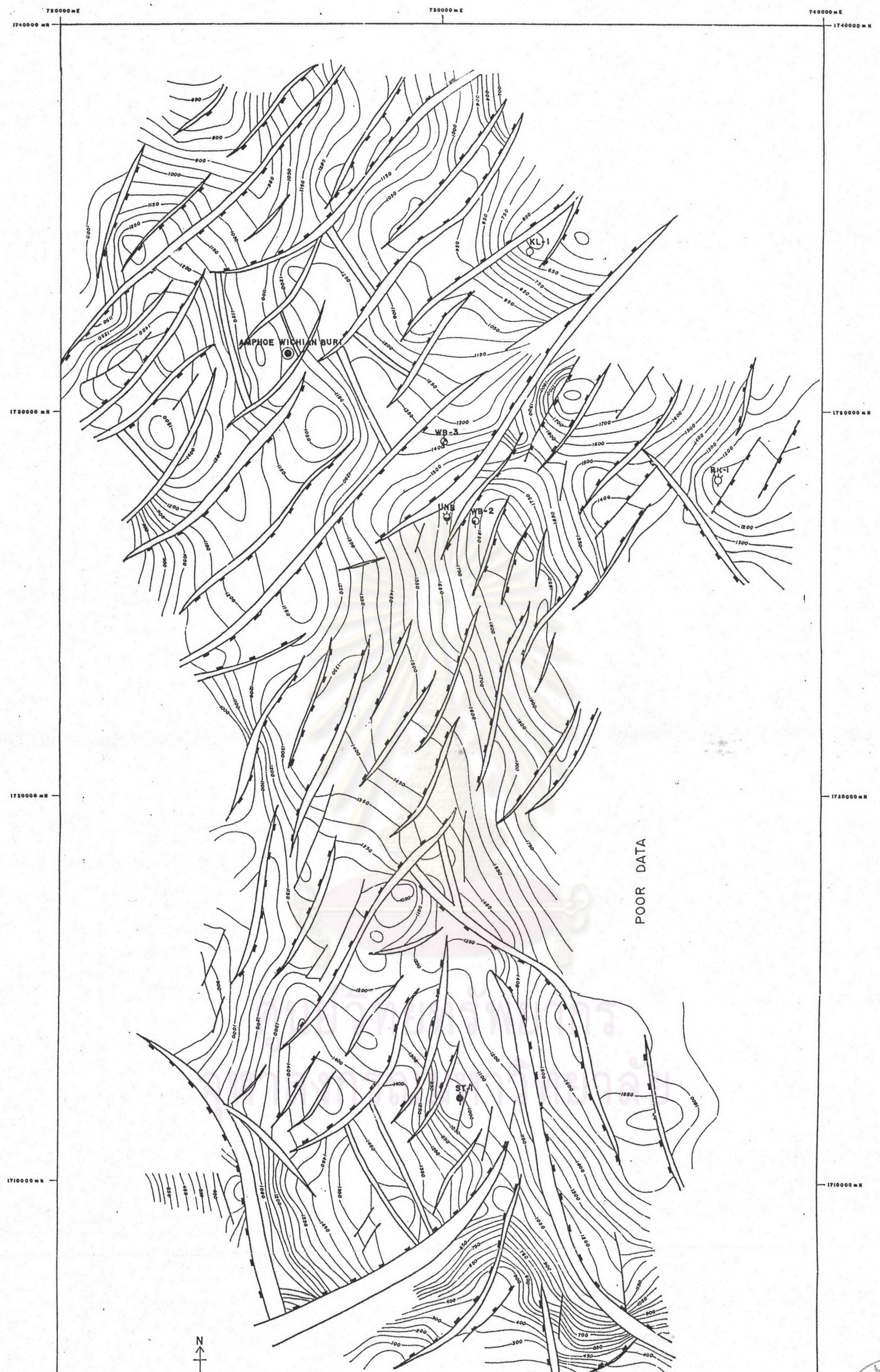


Figure 4.5b Interpreted seismic profiles of line ST-90-227 across the Si Thep-1 well, showing the presence of Si Thep type.



TIME STRUCTURAL MAP

TOP OF BASEMENT

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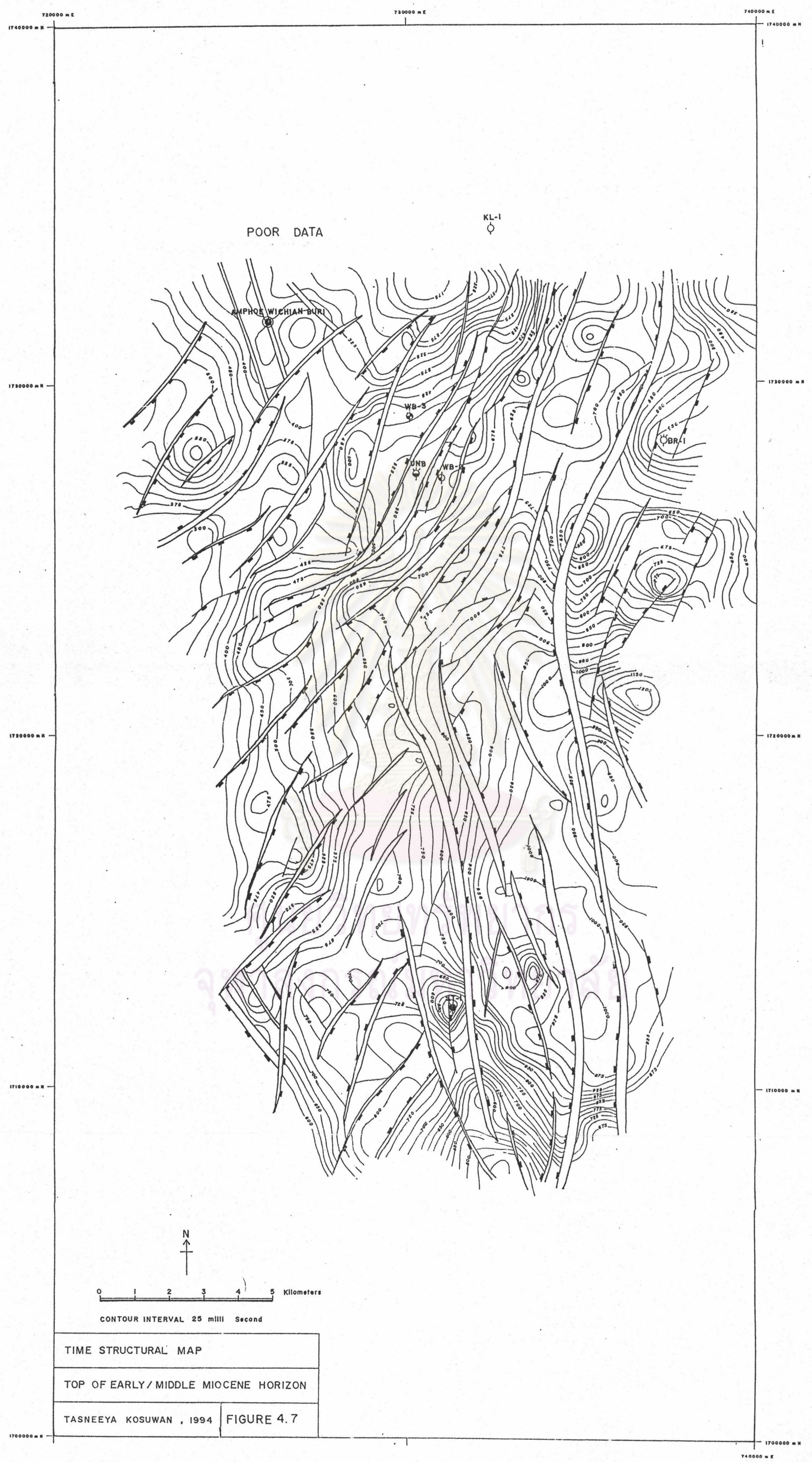
FIGURE 4.6

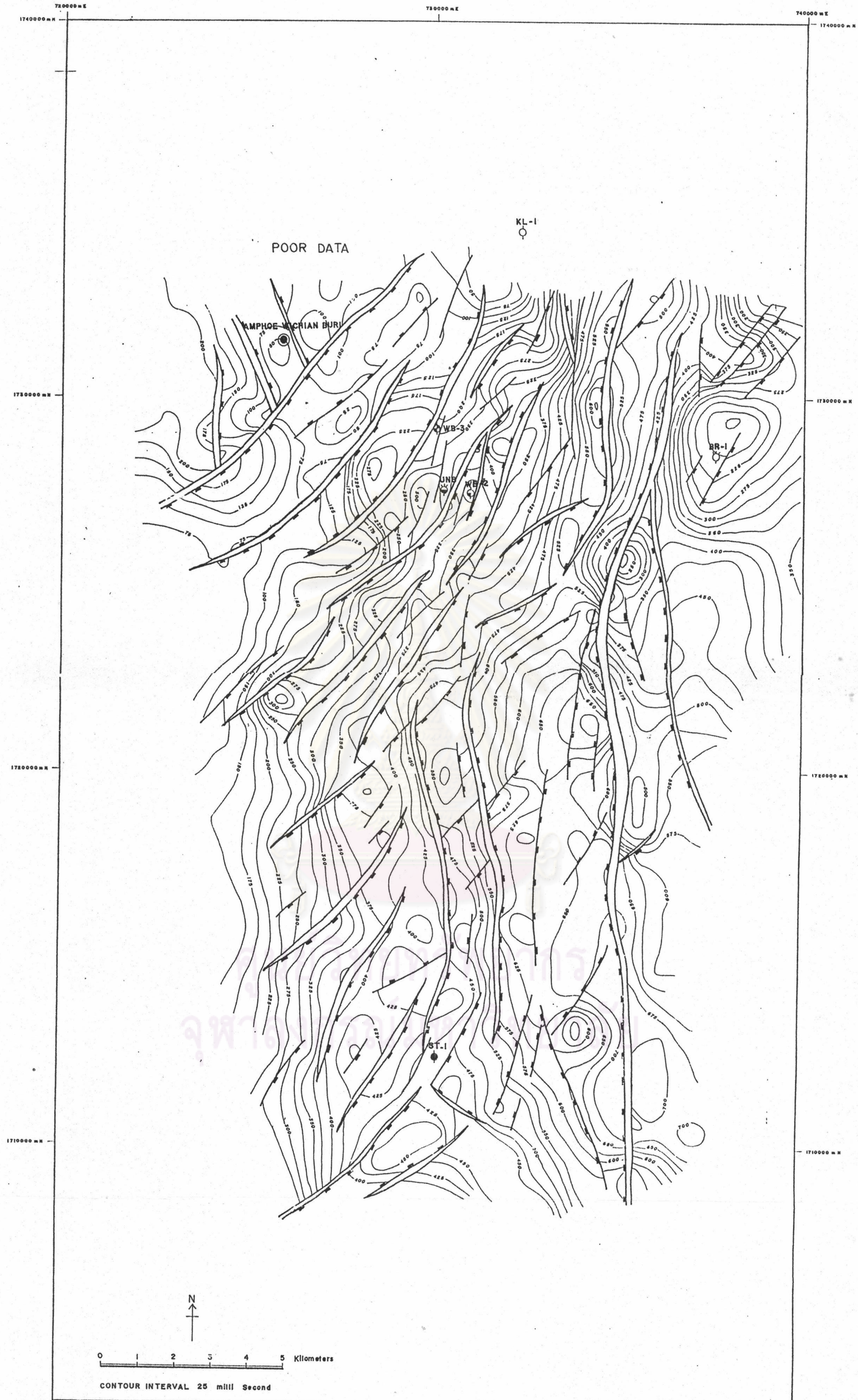


TIME STRUCTURAL MAP

TOP OF EARLY / MIDDLE MIOCENE HORIZON

TASNEEYA KOSUWAN , 1994

FIGURE 4.7



TIME STRUCTURAL MAP

TOP OF MIDDLE / LATE MIOCENE HORIZON

TASNEEYA KOSUWAN , 1994

FIGURE 4.8

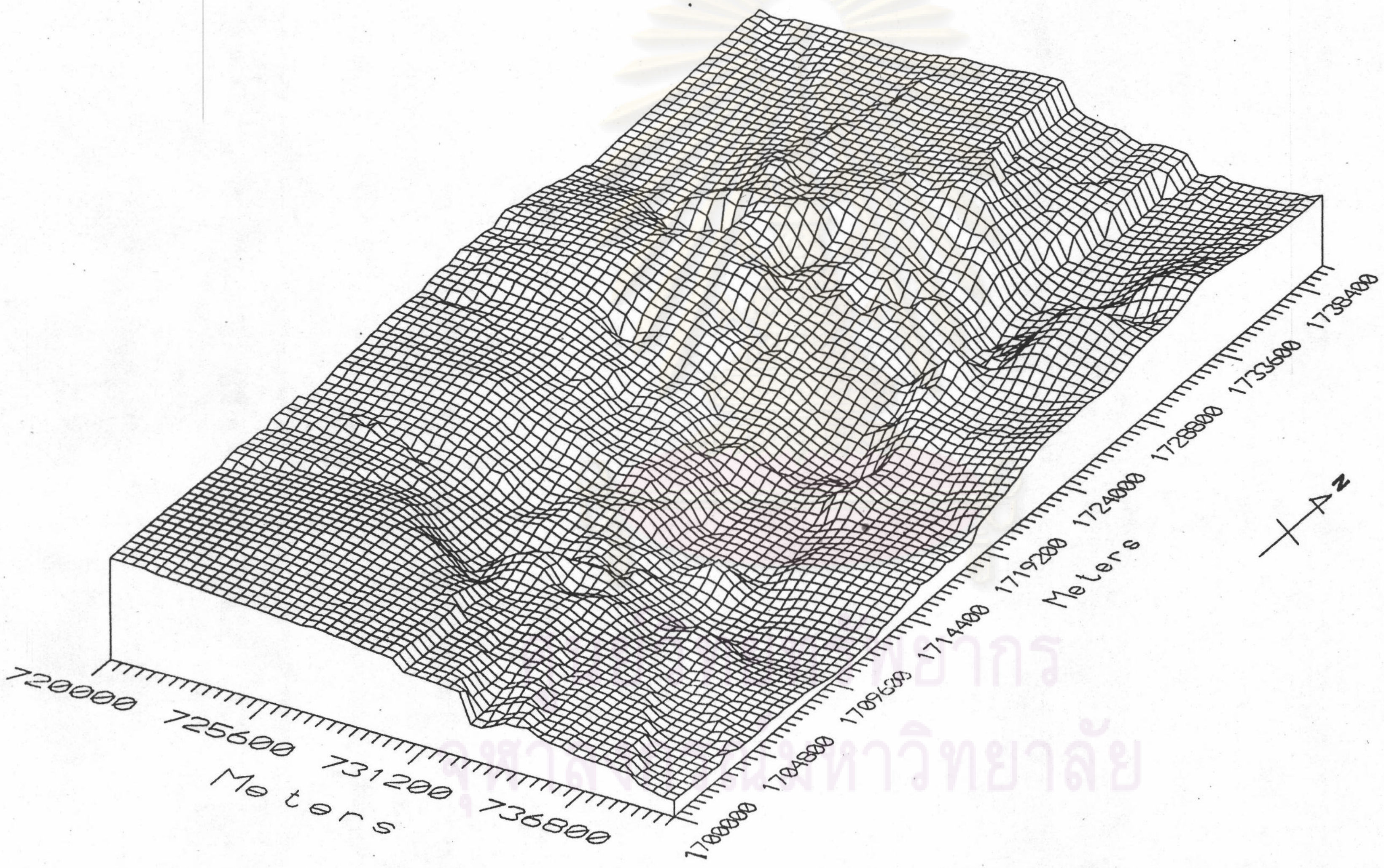


Figure 4.9 Topography of Early/Middle Miocene horizon.

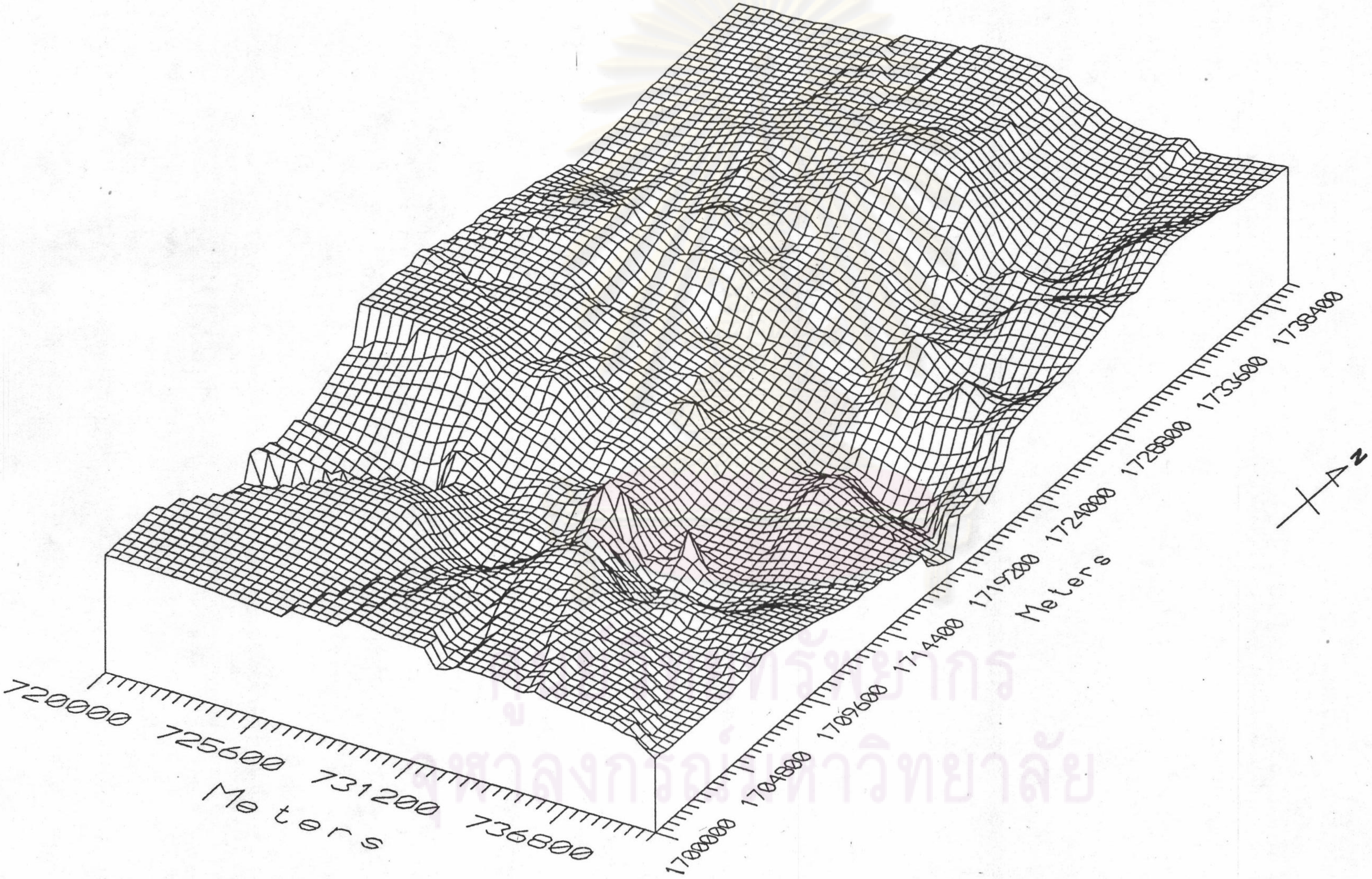


Figure 4.10 Topography of Middle/Late Miocene horizon.

volcanic rocks, basaltic tuffs, diorite and diabase intrusive bodies. Radiometric dating of igneous rocks in wells is shown periodic magmatism, beginning during the Early to Middle Miocene (11.6-15 Ma)(Webster, 1989). During period of rapid subsidence, the Wichian Buri sub-basin have experienced a higher extension rate. This may result in sufficiently rapid thinning of the crust to generate adiabatic melting in the mantle and result in intrusive igneous activity in the basin during Eary to Middle Miocene time. Emplacement of intrusives was probably accompanied by eruption of volcanics. This interpretation is based on the presence of the sills which are present within the WB-1 Formation that posses many similarities to volcanic rocks. Basaltic tuff at the base of the WB-3 Formation have been used to support this idea of major volcanism associated with intrusion within the Wichian Buri sub-basin.

The evidences of igneous activities in the Wichian Buri sub-basin are recognized in two ways. Firstly by the present of igneous sills or flows associated within the basinal formations from every wells except the Si Thep-1 well. And another evidence as indicated by seismic reflection data which showed that high-amplitude reflections can be generated from bodies of igneous intrusive rocks. Analysis of reflection data collected over the area suggests that the igneous layer encountered in the wells, or an equivalent layer at the same stratigraphic level, occurs over a large part of the sub-basin. However, these igneous bodies act as an acoustic barrier which little energy is transmitted. These make imaging deeper reflectors, particularly on the eastern side of the basin problematic. The widespread eruption of igneous rocks represents a large thermal input into the crust and may have occurred with a major change in the tectonic evolution of the basin. Seismic study has shown that the orientation of igneous bodies in the Wichian Buri sub-basin generally appears to be elongate in N-S trend. The orientation along N-S direction is conformable with the regional N-S trending extensional fractures during the Oligocene age which resulted in the opening of the Gulf of Thailand and Andaman Sea. Therefore, it leads to the conclusion that eruptions of the Late Cenozoic igneous rocks may have been related to the reactivated extensional fractures resulted by released pressure after collision between Indian and Eurasian Plates (Jungyusuk and Khositanont, 1992).

Two major events of igneous activities occurred within the Wichian Buri sub-basin giving two igneous groups which can be distinguished from the difference in log character and mineralogy.

The first igneous activity occurred in Early/Middle Miocene time from K/Ar dating of samples from the unpublished well which have yield ages of about 15 Ma (Remus et al., 1993). This igneous group is characterized by a very low GR response and comprises of both intrusives and pyroclastics. They are represented by basaltic tuffs at the base of WB-3 Formation in the unpublished, Wichian Buri-2, and Wichian Buri-3 wells as well as thick intrusives penetrated in the unpublished, Bo Rang-1, and Khao Leng-1 wells. The intrusives are diorite and diabase sills those composed predominantly of plagioclase, pyroxene and hornblende. These units are fine-grained with subophitic or lathwork textures, suggesting rapid cooling. Eruption of this igneous group has been interpreted to be related to the early phase of crustal extension in the region.

The second igneous activity occurred in the time not much different from the first activity. The intrusives were penetrated between 339-352 m.and 1144-1439 m. in the Bo Rang-1 well and K/Ar dating of this sill indicates a Middle to Late Miocene age of emplacement (11.6 Ma)(Remus et al., 1993). This igneous group is characterized by a higher GR response, reflecting the increase of alkali feldspars and biotite content. The sill may have been intruded in the same time with surface Wichian Buri basalts which are alkaline basalts and K/Ar radiometric age determination yielded 9.7 to 11.6 Ma (Charusiri et al., 1990).

Tectono-sedimentary Evolution

The primary purpose of this section is to put the deposition events related to the development of this basin into the broad context of depositional history in the area extending from Oligocene through Recent.

Sediments within the Wichian Buri sub-basin are entirely non-marine sediments, including fluvial and lacustrine sequences. Their accumulation occurred during a time of relative tectonic quiescene. It is proposed that the basin may have been formed by large-magnitude of crustal extension in Oligocene-Recent, and this region represents major Late Cenozoic rift. The Tertiary sedimentary rocks of the basin are considered to represent their deposition which in turn reflecting differential subsidence within several developing, extensional, rift half-garben sub-basin. It is tectonic significance because it appears to span a transition from fault-controlled subsidence to a phase of thermally driven subsidence at the end of Middle Miocene.

The sedimentological and tectonic evolution of the Wichian Buri sub-basin is dominated by two principal extensional phases during Oligocene-Recent. An early phase of crustal extension in the region is characterized by major normal faulting leading to basin formation, and intrusions during Oligocene-Middle Miocene. During this time, the deposition was mainly controlled by the border fault movement and mainly extendly in N-S direction. Rapid Oligocene-Early Miocene subsidence which is fault-controlled subsidence produced the half-garben geometry of this basin. The style of extension changed in late Middle Miocene. The late stage is characterized by renewed basin growth concided with structural inversion. Renewed subsidence is considered to be thermally controlled subsidence. Pliocene - Pleistocene inversion achieved by reversal of the direction of extension to more E-W structural control on sedimentation.

Oligocene to Middle Miocene

Two major phases can be deduced from data presented here in combined with that from previous studies. The evolution presented below is restricted to the early stage of tectono-sedimentary evolution of the Wichian Buri sub-basin only.

Phase A : Basin Opening

Consequently, the collision of Indian Plate with Eurasian Plate was the cause of reversal movement of Mae Ping fault zone from sinistral in Mesozoic to dextral in Tertiary. The major dextral movement along NW-SE trending faults including the Red River, Mae Ping and Three Pagoda fault zones is believed to have occurred in the Oligocene and it resulted in large-scale dextral shear stress in the block between this faults. This shear stress may be expected to cause the major extension of the Tertiary basins during rifting in this region. Faults with a dominant N-S orientation were re-activated under extension, and sedimentary basins including the Wichian Buri sub-basin, were formed.

The timing of basin opening and initial sedimentary deposits are poorly envisaged because of lacking diagnostic age fossils. From the general conclusion, the ages of the oldest sediments occurring in the Tertiary basins of Thailand are Oligocene. Based on ages of the Nong Bua Formation, the oldest sequence of the Phitsanulok Basin which has lithology similar to the WB-1 Formation of the Wichian Buri sub-basin. Thus, radiometric dating of igneous layer in a well indicates lastest Early Miocene for intrusion. The opening of the basin began before this because the igneous units intruded the syn-rift sedimentary rocks. Therefore, the Oligocene is considered to be the time of initial basin development.

Phase B : Basin Fill (Fault-controlled subsidence)

The Late Oligocene-Middle Miocene fill of the Wichian Buri sub-basin comprises of the WB-1, WB-2 and WB-3 Formations. These formations were deposited during the continued motion along the border faults and were characterized by marked increases in thickness of sections on the downthrown side of these faults. During this time extension was mainly controlled by border faults.

The oldest basin fill which deposited during the initial stage of basin development in Late Oligocene, represented by the fluvial deposits of the WB-1 formation. It overlies unconformably on Permo-Triassic metasediments and volcanic rocks. This formation consists of varicoloured claystone interbedded with sandstone and weathered fine-grained volcanic rocks which accumulated due to extensional forces. These alluvial sediments were deposited in a river system ancestral to the present day Mae Nam Pa Sak and interpreted as alluvial plain deposits. The presence of volcanic rocks associated with sediments in the WB-1 Formation indicates that rifting began with the oldest formation. However, although the deposition of the basin began in the Late Oligocene with fluvial sedimentation of the WB-1 Formation, but the main phase of basin development began in the earliest Miocene with high rate of subsidence.

At the beginning of Early Miocene, under the dextral tectonic regime, the rate of extension rapidly increased, leading to a pronounced increase in the asymmetry of the half-garben, sagging of the basin floor along the border faults. This is believed to be associated with the increase of structural activities, especially the re-activation of existing major faults, Mae Ping and Uttaradit Fault Zones. At this time, total subsidence was greater than sediment influx and the basin deepened rapidly leading to the creation of a large lake. A persistent lake occupied most part of the basin resulted in the deposition of thick, organic-rich claystone of the WB-2 Formation which represents lacustrine environment of deposition. The lacustrine deposits are widespread especially in the center and southern part of the basin. In addition, fault subsidence which was rapid and continuous enough so that coarse material rarely buildout into the lake, as shown by the complete lack of sandstone and minor amount of silt-size sediments in the WB-2A Member.

Interpretation of seismic reflection profiles and well data, lacustrine condition was established across the basin. And water depth in the basin was probably great, this estimaties based on the maximum known thickness (1260m) of the WB-2 Formation. Lacustrine strata of the WB-2 Formation thicken and were deposited under deeper water conditions from the lateral edges toward the center of the basin, indicating that the basin generally subsided more at its center than at its edges, reflecting along-strike variation in displacement on the entire border faults. Accordingly, the greastest subsidence has occurred at a N-S fault running along the central axis of the basin. This N-S extension was major trend extension that has persisted through this history time of the basin.

While the basin became more tectonically active , and a widespread lake developed, alluvial fans would have formed along the fault margins. Lower gradient drainage patterns were likely to have been developed along pre-existing structural lows thus clastic sediments encroached upon the lake margins, and shed prograding deltas into the basin, causing long-life lacustrine environment in the basin being interrupted by a period of high sediment input and rapid delta progradation accordingly leading to detaic-lacustrine environment. The coarsening-upward deltas are relatively thin (1-2m.) but are widespread (tens of kilometers). Because they occur so frequently during the infilling process, they account for a significant volume of basin sequence. Repeating of the thin deltaic layers indicates several short-life periods of delta progradation, which might be related to short-life tectonic events or climatic oscillations. From seismic profile, it shows the prograding deltaic sandstones derived from the lake margin of the basin and transported eastward into the basin along downslope (Figure 4.4b). This leads to the interpretation that the sedimentation at this time was in the open lake condition.

In Middle Miocene, compression along the sheared margin causes the activity of the fault system tend to decrease concomitant with the uplift of the crust. These resulted in the marked declination of the rate of subsidence. The total subsidence was then less than sediment influx and basin became shallow. The lake gradually regressed coincidental with the increasing fluvial influence through time. After tectonic subsidence ceased, the basin drainage became reversal. This action resulted in an extensive fluvial deposition occupied over the area during the Middle Miocene time, although small lakes persisted in some area. This is evidenced by the presence of thick, cleaner, river sandstones of the WB-3 Formation.

There are possible two significant unconformities within the Early-Middle Miocene sedimentation (Figure 4.11a & b). The older unconformity related to local tectonic and igneous activity is recognised at the base of the WB-3 Formation by the appearance of a unit of basaltic tuff in the unpublished, Wichian Buri-2 and Wichian Buri-3 wells and thick intrusives equivalent penetrated in the unpublished, Bo Rang-1, and Khao Leng-1 wells. Onlap of the underlying strata is evident on seismic data in some areas of the basin, indicating the local unconformity. Radiometric dating of the intrusive and basaltic tuff samples indicates an Early / Middle Miocene age (approximately 15 Ma). The initial magmatism represents a large thermal input into the crust and may provide a possible explanation for this local uplift.

A second major unconformity appears at the top of the WB-3 Formation was

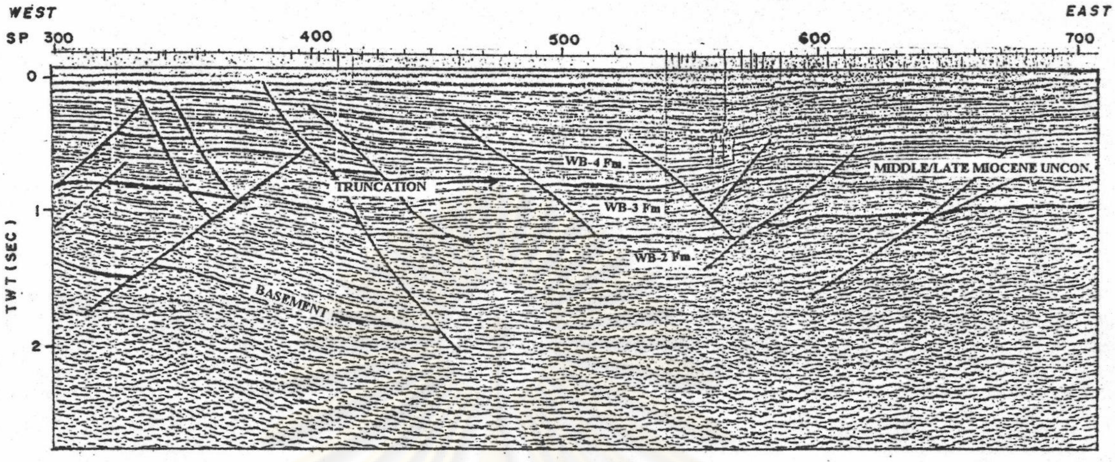


Figure 4.11a Interpreted seismic profile of line NB-89-01, showing the Middle/ Late Miocene unconformity onlap of the WB-3 Formation are truncated by the overlying WB-4 Formation.

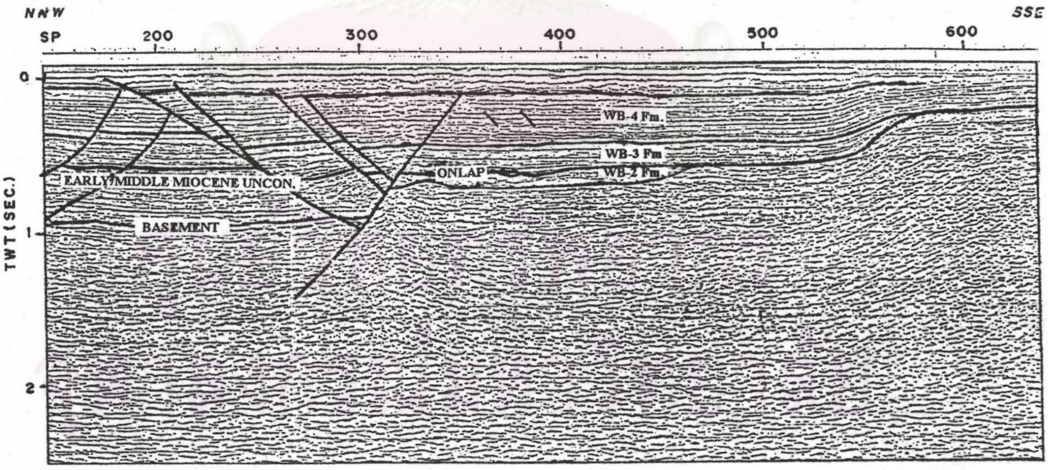


Figure 4.11b Interpreted seismic profile of line ST-89-204, showing onlap of the WB-3 Formation onto the underlying WB-2 Formation.

a result of regional tectonic uplift. The Middle / Late Miocene unconformity is identified by a change in palynological assemblage, offsets in electric logs, and onlap and truncation on seismic data. The change in palynological assemblages from a tropical palynological assemblage in the Lower to Middle Miocene to a temperate assemblage in the Late Miocene, reflects a climatic change associated with eustatic sea level fall due to widespread tectonism in South East Asia at the end of the Middle Miocene. The sill encountered in the Bo Rang-1 well have yielded radiometric as old as about 11.6 Ma, comfirming tectonism associated with the Middle/Late Miocene event.

Due to the fact that the Wichian Buri sub-basin preserved a long history of igneous activity, continued emplacement of magmas thus resulted in a block of hot rock that move upward as a buoyant diapir. This has produced an extreme structural high for this region. The presence of the Bo Rang structure is considered likely to be the uplifted remnants of the basin.

Late Miocene to Recent

Phase A : Renewed Basin Growth (Thermal Subsidence)

According to the second phase of tectonism coincidental with a marked climatic change occurred at the end of the Middle Miocene, the sedimentary record of this event was marked initially by the renewed basin growth with subsidence and sedimentation. It is believed that this subsidence was a consequence of cooling phase of the heated and streching lithosphere. Thermal subsidence seems to be very likely because major thermal events are known to have preceeded this stage.

In Late Miocene, a renewed sedimentary cycle was similar to that of Early to Middle Miocene. The thermal subsidence began with the deposition of a predominantly claystone succession of the WB-4 Formation overlies on the Middle/ Late Miocene unconformity. This indicates the widespread return of lacustrine condition around newly formed areas of higher relief which were surface expression of large igneous intrusives at depth. There was no evidence of igneous activity in the WB-4 Formation. However, subsidence and sedimentation persisted locally in the most part of the basin until Pliocene. These strata were uplifted and truncated along the margins of the Wichian Buri sub-basin during the Pliocene-Pleistocene time before the deposition of the overlying younger strata.

Phase B : Block-faulting

Following the Late Miocene-Pliocene deposition, extension shows a more E-W direction. Extension was then controlled by a set of east and west-dipping listric normal faults. This faulting took placed in a brittle regime where extension segmented the basin into numerous NNW-SSE and few NNE-SSW fault blocks. Most site of extension shifted eastwards. From seismic reflection profiles (Figure 4.4a & b) these fault blocks show rotation down to the west accompanies a eastward displacement. Crustal extension occurred in an E-W direction during Pliocene is resulted to subduction of the Indian plate under the Andamen Islands and western Burma (McCabe et al., 1988)

Phase C : Deposition of Quaternary Sediments

The third unconformity lies within the Pliocene. This horizon is seen to truncate the WB-4 Formation on seismic data (Figure 4.4a). Oxidising fluvial condition resumed following this event.

The Wichian Buri Sub-basin Model

It is generally accepted that sedimentary basins were formed by processes of lithosphere extension. There are two ideas on the development of the Tertiary basins in Thailand. The early idea showed that these basins have been characterized as a product of pure-shear model of McKenzie (1978). It is believed that the development of the Tertiary basins in Thailand was the results of plate motions in S.E Asia closely related to the movements of Indian Plate toward Eurasian Plate, sea-floor spreading, rifting and emplacement of granites in this region (Achalabhuti 1974; Woolands and Haw ,1976; Pradidtan ,1987). Most of geologists defined these basins as the rift basin. The later idea which is widespread accepted, showed that these basins have been characterized as a product of simple shear model of Wernicke (1985). This new idea was complied by Polachan and Sattayarak (1989), they suggested that the extension of the Tertiary basins in Thailand occurred along major strike-slip faults resulting to Indian and Eurasian Plate interaction during the Early Cenozoic. These basins are classified as the rift / pull apart basin.

The Wichian Buri sub-basin is bounded by the NNE-SSW and NNW-SSE oriented faults. Under the dextral shear stress, these faults with a dominant N-S orientation were activated responding to the reversal of movement of major strike-slip faults in this region during the Oligocene time, resulting to the collision between continents as mentioned above. Extension related rifting may have begun in this time with the break up of basement into a series of highs and adjacent depressions filled with Oligocene to Recent sediments. During rifting, most of the extension in the Wichian Buri sub-basin is accommodated along the border faults that has been confirmed by the seismic profile in Figure 4.3c. This showed that the many gentle dipping, listric faults merge at their base into a master detachment surface that dips gently through the crust. Following the Late Oligocene, the Wichian Buri sub-basin may have experienced a higher extension rate with rapid subsidence lead to lacustrine conditions established over the basin. And this may resulted in sufficiently rapid thinning of the crust to generate adiabatic melting in the mantle, result in intrusive igneous activity and increase in geothermal gradient in the basin during Early to Middle Miocene time. The end of syn-rift period was marked by regional uplift at the end of Middle Miocene.

A second stage of basin growth with renewed subsidence and sedimentation is in the post-rift (or drift) phase prior to Late Miocene. Rate of subsidence during drifting phase is considered to be slower than those in the syn-rift phase. Based on lithology of the WB-4 Formation, the presence of sandstone interbeds in the claystone-dominant sequence, especially in the lower part of the sequence and the colour of claystone is light grey or greenish grey, these indicated the deposition in shallow lake condition. The author would like to suggest that the shallower water was caused by the slower subsidenence than before. It is considered that thermal contraction after rifting was the major driving mechanism for the post-rift subsidence (thermal subsidence). This is explained by streching model of McKenzie (1978) that in cooling of the uplift hot material back to the equilibrium gradient which existed before streching causes an increase in density and resultant subsidence combined with sedimentation. Following the Late Miocene to Pliocene deposition, extension caused the basin into numerous rotated fault-block segments which covered by Quaternary deposits after the Pliocene-Pleistocene uplift.

As the result, the extension in the Wichian Buri sub-basin can be explained by a combination of simple shear and pure shear models. It concluded that the Wichian Buri sub-basin is a rift basin.

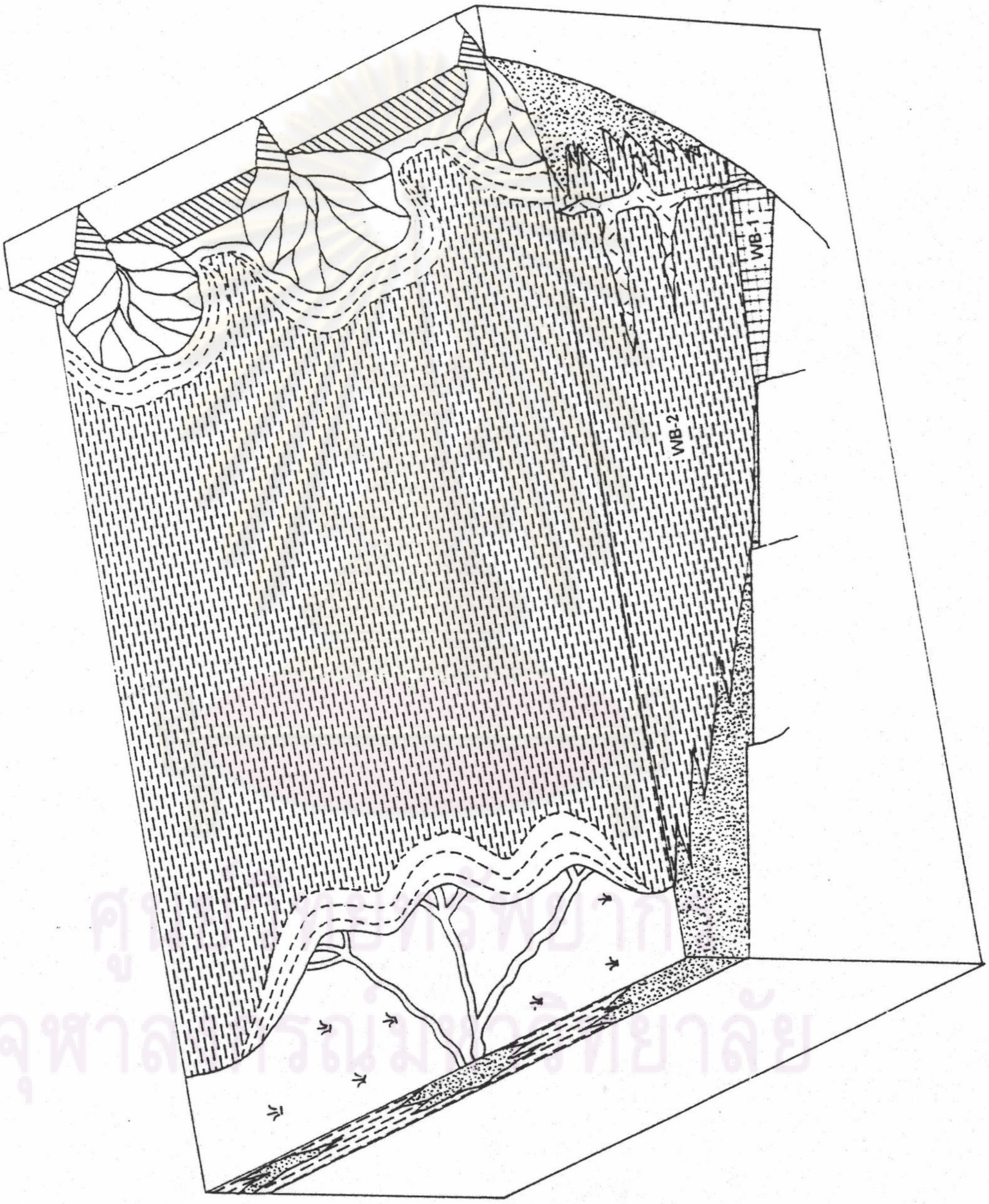


Figure 4.12 Idealized paleogeographic reconstruction in Early/Middle Miocene.

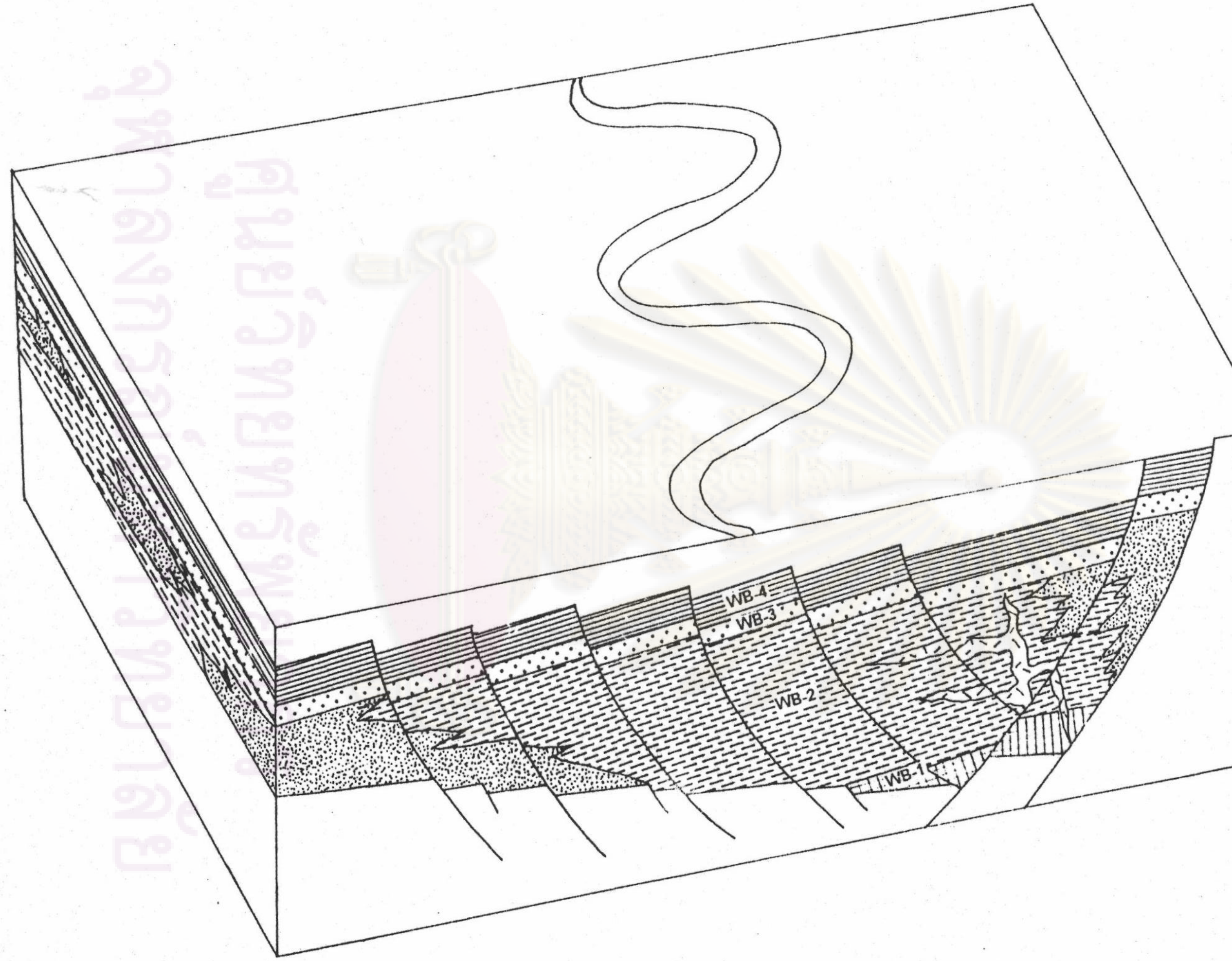


Figure 4.13 Idealized paleogeographic reconstruction in Recent.