Tectono – Stratigraphic Evolution of The Ayutthaya Basin, Central Thailand

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Abstract

The Ayutthaya Basin is a major Cenozoic basin in central, Thailand. The basin is bounded to the North by the Northwest – Southeast trending Mae Ping Strike-slip Fault Zone (MPSFZ). Oil footprint was recorded from the first well drilled in 1980. However, the basin has not been the focus interested for petroleum exploration for over 30 years due to high uncertainties in petroleum system. Due to the poor quality of 2-D seismic data, internal basin structures have not been analyzed for understanding basin mechanism and the development of petroleum system. Therefore, this study aims to propose a structural evolutionary model of the Ayutthaya Basin and describes the influence of tectonic activities on petroleum system with discussion of similar Cenozoic basins.The method of this study uses a seismic interpretation of 2-D seismic data combined with well report and structural reconstruction analysis. The elongate Ayutthaya Basin is a North – South trending which is controlled by North – South trending pre-existing structure. The major faults are oriented in a North – South direction that show listric normal faults. The Cenozoic sedimentary unit is approximately 2,000 – 2,500 meters thick. It can be subdivided into seven units according to seismic characters and the well report including; Pre-rift, Syn-rift 1, 2, 3, Post-rift 1, Inversion, and Post-rift 2 units. There are four phases of basin evolution that can be identified by seismic interpretation and structural reconstruction which from older to younger events: (1.) an extensional phase in Late Oligocene? – Early Miocene (2.) subsidence phase and sagging in Middle Miocene (3.) local inversion phase in Middle – Late Miocene and (4.) regional subsidence from Pliocene – Recent. The average stretching factor (β) along the basin axis is approximately 1.18. Structurally, the Ayutthaya Basin resembles the Bohai Bay Basin in China, which formed in transtensional system. The MPSFZ affects the Ayutthaya Basin due to the randomly inversion and basin geometry changing. The possible reason of no petroleum potential in the Ayutthaya Basin is that there is lack of petroleum system which is no source and seal potential. Furthermore, the hydrocarbon cannot be generate due to no heat source.

Keywords: Ayutthaya Basin, Structural reconstruction, Cenozoic basin

1. Introduction

Major energy resources in Thailand are from the Cenozoic basins. In the Gulf of Thailand, many gas fields are in these basins, such as Pattani and Malay Basins. Onshore oil fields are mainly located in the central plain of Thailand where total reserves of 5-30 million barrels of oil are estimated from the Kampheng Saen and Suphanburi Basins. The Ayutthaya Basin is one of th Cenozoic basins in the central plain area. It is located approximately 50 km.to east of the Suphanburi Basin. However, the Ayutthaya Basin has been considered as a low potential area for petroleum exploration (O'Leary, 1987). In 1980, the first well, BP1-W04, was drilled in the basin by BP Oil Company and an oil footprint was recorded from the well. In this case, tectonic evolution may be an answer of this situation. The central plain area has a complex tectonic evolution that might have affected the petroleum system.

This research aims to propose an evolutionary model of the Ayutthaya Basin. and describe the influence of tectonic activities during the Cenozoic Era on petroleum system in the basin. Well report and 2D seismic data used in this study are provided by the Department of Mineral Fuels, Thailand (DMF).The Ayutthaya Basin has approximately 2,790 km2 (Fig 1).

2. Geology

The Ayutthaya basin is located in lower central plain of Thailand which is an elongate basin. This basin has approximately 2,790 km2 and forms a half-graben with a North – South trend. In central Thailand, the large alluvial-dominated plain, consists of three sub-segments, namely Upper Chao Praya, Lower Chao Praya,

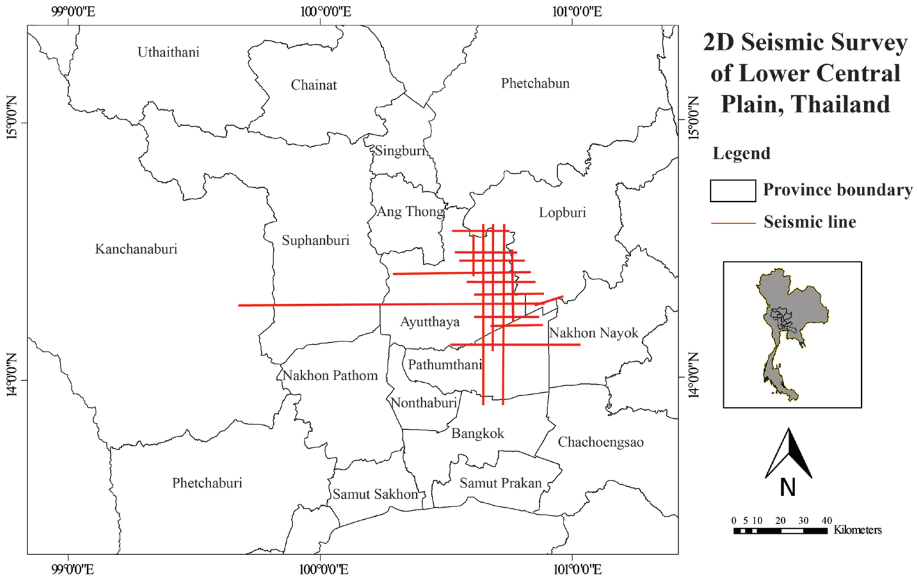

Figure 1: The study area of lower central plain, Thailand that shows the seismic survey in red lines covered in Ayutthaya, Lopburi, Pathumthani, Nakhon Nayok, and Suphanburi Provinces.

and Phetchaboon sub-segments (Charusiri and Pum-Im, 2009). The Lower Chao Praya Sub-segment is limited to the North by the Mae Ping fault. Shape of the segment is delineated by the Mae Ping (Morley, 2007) and Kham Pang Saen Fault Zones. Central plain Thailand Basin occurred during Eocene which has two structural styles that controls the basin morphology.

Quaternary sediments represent a complex sequence of alluvial, fluvial and deltaic sediments were deposited in the basin (Sinsakul, 1998). The upper 600 meters of the Pleistocene and Holocene unconsolidated sediments are separated by thick confining clay of sandy clay layers (Ramnarong and Buapeng, 1992). (Fig 3 and 4).

2.1 Cenozoic Basin development of Thailand

Major sites of basin development of the Cenozoic basin were within India and Asia subduction and continental collision. Cenozoic basins in Thailand are classified as intracratonic rift basins by Woolland and Haws (1976), Chinbunchorn et al. (1989) and as transitional pull apart basins by Polachan and Sattayarak (1989) and O'Leary and Hill (1989), and as major continental rifting basins (Charusiri and Pum-Im, 2009). Four phases of basinal development are recognized herein and interpreted based upon the plate-tectonic regime

(1) Pull-apart and syn-rifting phase interpreted based upon the plate-tectonic regime The first episode of basin formation commences with the onset of transtensional rifting in which predominantly N – NNW trending extensional troughs. Tectonic style changed from passive continental margin to subduction convergent margin by the interaction of India – Asian which may have occurred during 55 Ma (Charusiri and Pum-Im, 2009). Resulting in this phase, half graben – type basin of Late Eocene - Late Oligocene may have been created. Mid –Tertiary Unconformity (MTU) was occurred and observed by seismic data (Jardine, 1997).

(2) Quiescent thermal subsidence phase

Pure extension in the basin decreased and transtensional tectonic were occurred in late Oligocene. Mantle plume by thermal contraction may trigger extension of the basin. The strengthening of the lithosphere resulted in tectonic strain, forming the widening basin by strike-slip movement (Bal. et al, 1992). and may have developed onwards. Rapid extension and deepening resulted in graben to half-graben type fault system.

(3) Transpressional wrenching phase

Dextral shear continuing produced a tectonic style changing into transpressional in

Late Middle Miocene, resulting in folding and inversions of the Cenozoic basin of Thailandin the end of Late Neogene. The evidence of this phase is represented by the Mid – Miocene to Early Late Miocene unconformity (MMU) which the Gulf and the central part of Thailand were observed from geophysical signal (Makel. et al, 1997). The changing in transtensional to transpression styles in northern – central Thailand resulted in the decreased subsidence rate. Densely faulted graben systems formed the main structural traps of hydrocarbons in the complex development basin due to this phase.

(4) Post – rifting phase

After transpressional phase, the Gulf and central Thailand basin have in significant of tilting or rotating due to transgression and marine deposit in upper Miocene. As a result, fluvial/ alluvial sediments were deposited in the entire region (Charusiri and Pum-Im, 2009).

2.2 Suphanburi Basin

Suphanburi and Kamphaeng Saen Basins were explored by BP in 1980s and later explored by PTTEP. The basins are half graben and North – South trending with western boundary fault system. The sediment in early syn-rift is filled by lacustrine sediment and predominantly fluvio – alluvial deposits in later (Morley and Racey, 2011).

2.2.1 Structural Geology

Suphanburi Basin is located between two major active strike–slip faults which is Mae Ping Fault zone and Three Pagodas Fault zone (Fig 5). It is a half graben basin and North – South trending (Polachan et al., 1991) which have a series of Northwest – Southeast trending and Northeast – Southwest trending. This basin is probably controlled by two major strike–slip faults. The Mae Ping fault and Three Pagodas fault may occur in Pre–Cretaceous with sinistral movement (Bal et al., 1993) and may have dextral movement in Post–Cretaceous. During dextral movement, these two fault zone developed the rift generating tensional pull–apart basin with both synthetic and antithetic normal fault in North – South trending (Charusiri et al., 2000) and minor fault appeared in Late to Middle Miocene (Pradidtan and Dook, 1992).

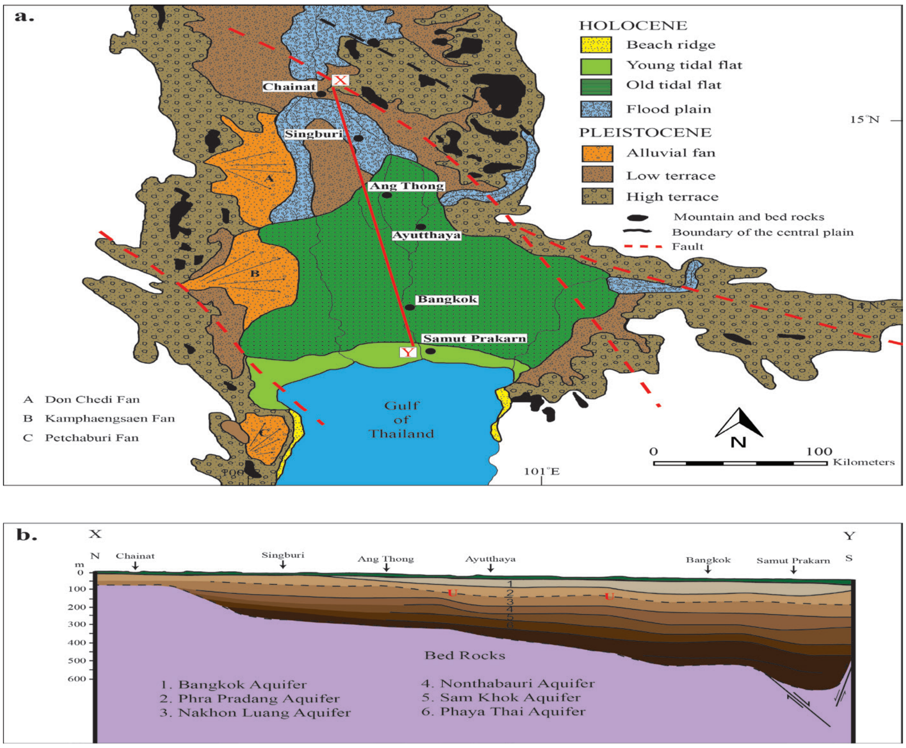

Figure 3: (a.) Geologic map of Quaternary deposits in the Lower Central Plain (Modified from Dheeradilok, 1986). (b.) North – South (X-Y) profile of the hydrogeologic strata (Modified from Ramnarong and Buapeng, 1992).

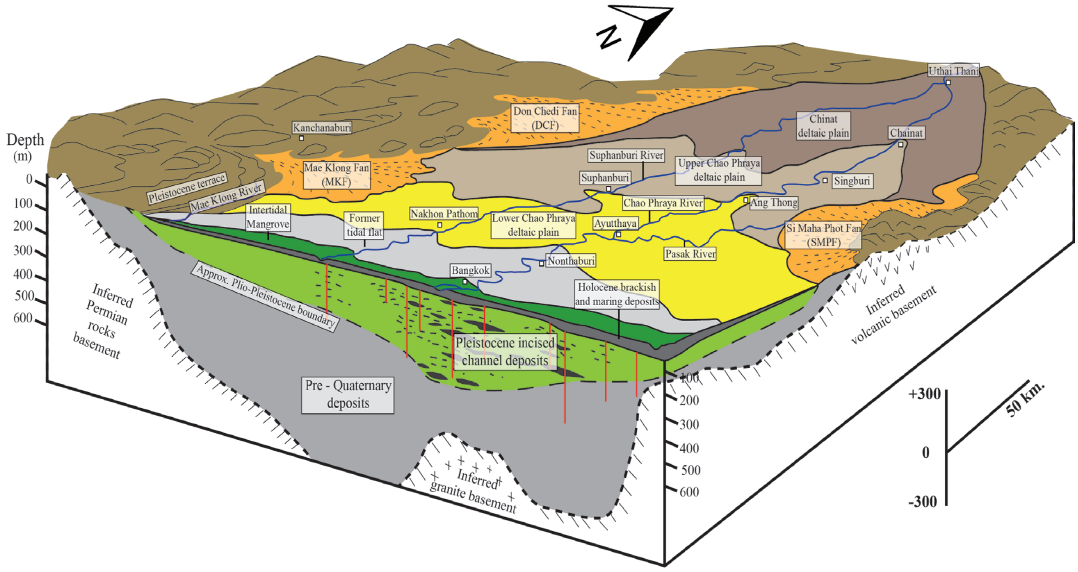

Figure 4: 3-D diagram of the Lower Central Plain and distribution of Quaternary deposits (Modified from Choowong, 2011)

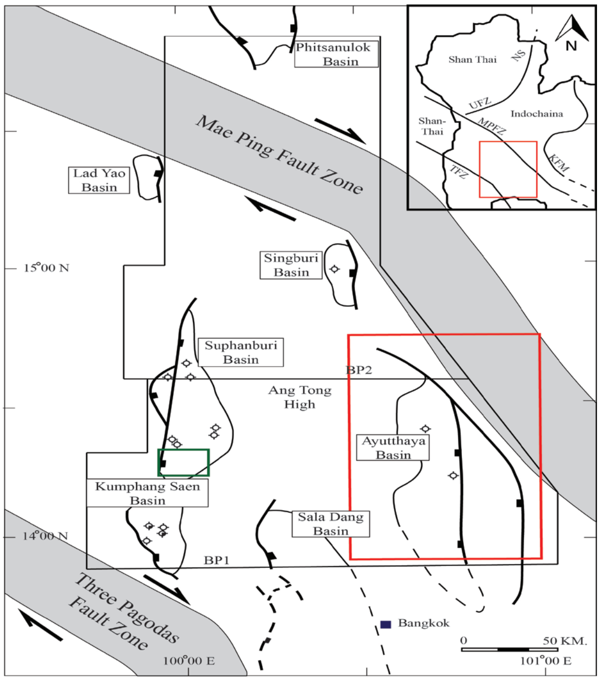

Figure 5 The Cenozoic basin of BP2 and BP1 blocks in Lower Central Plain, Thailand; red rectangle referred to the study area (Modified from PTTEP, 2000); TFZ - Three Pagodas Fault Zone, UFZ - Uttaradit Fault Zone, KFM - Khorat Frontal Monocline, MPFZ - Mae Ping Fault Zone, NS - Nan Suture

3.5.2 Stratigraphy

In 1995, BP Oil Company divided Tertiary sedimentary rocks into 8 units (S10 – S80), but PTTEP separated 5 units (Fig 6) including;

(1) Pre – Tertiary rocks

Basement rocks of Suphanburi Basin consist of limestone, granite and metamorphic rocks in Pre – Tertiary age.

(2) Unit A, equivalent to sequence S80

This unit comprises of sandstone and conglomerate interbedded with siltstone, shale and some limestone in Lower Oligocene. The thickness is 160 meters in edge of the basin and up to 370 in middle of the basin.

(3) Unit B, equivalent to sequence S70

Claystone and shale interbedded with sandstone and siltstone of Upper Oligocene. This unit is 120 meters thick in middle of the basin and 70 – 110 meters in edge.

(4) Unit C, equivalent to sequence S70

Lower Miocene Sandstone interbedded with claystone. This unit is 120 meters in eastern, 320 meters in middle and 630 in western of the basin.

(5) Unit D, equivalent to sequence S60, S50 and S40

Middle to Upper Miocene Sandstone and siltstone interbedded with claystone. This unit has 630 meters thick in middle and 500 – 660 meters thick at the edge of the basin.

(6) Unit E, equivalent to sequence S30, S20 and S10

This unit is Pliocene to Recent age which consists of sandstone, siltstone, claystone and some limestone. It has more than 900 meters thick in the basin.

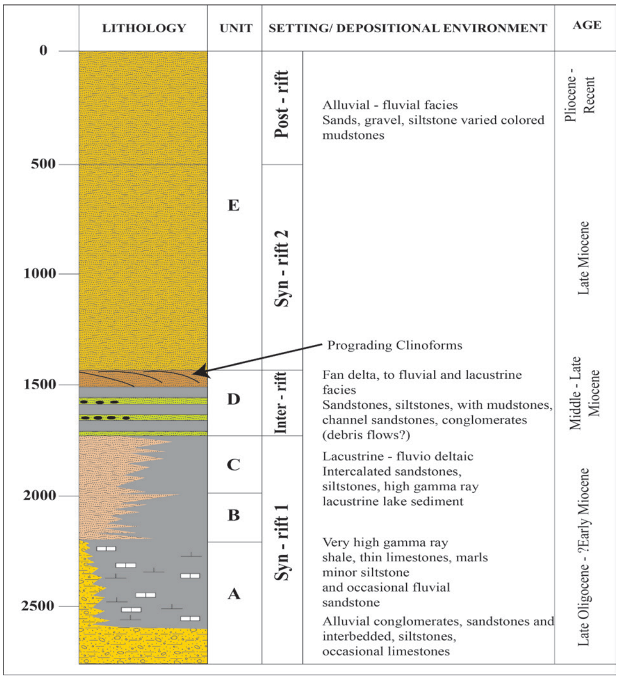

Figure 6 General Tertiary stratigraphy of the Suphanburi basin (Modified from Morley and Racey, 2011).

4. Methodology

This study focuses on identifying tectonic setting that controls structural development of the Ayutthaya Basin. The data sets include 16 lines of 2-D seismic survey and BP-1W04 well data from Department of Mineral Fuels (DMF) (Figure 1). Working plan begins with seismic interpretation and creates a seismo-stratigraphic chart. After that, a balancing technique is used to identify the basin evolution.

4.1 Seismic Interpretation

According to the regional tectonic, the basin trends in north – south. The cross-section in east – west trend is important to structural geometry and basin evolution. The perpendicular seismic lines are used to interpret the structural geometry of the basin, such as fault, corresponding seismic horizon to the tectonic events. The seismic horizons can be referred in color lines as shown in Table 1.

4.2 Well data

BP1–W04 was drilled as an exploration well which the Time – Depth conversion chart was also analyzed (Fig 7). This well was drilled by BP Petroleum Development Ltd., in 1986 where located in the AY–093 seismic line at 2000 m. TVD. (Fig 8).

Table 1
The seismic horizons and their color lines

Horizon Name	Color line	Line
Post – rift 2	Dark Blue	
Syn - inversion	Pale Green	
Post – rift 1	White Blue	
Syn – rift C	Pink	
Syn – rift B	Green	
Syn – rift A	Orange	
Pre – rift	Brown	

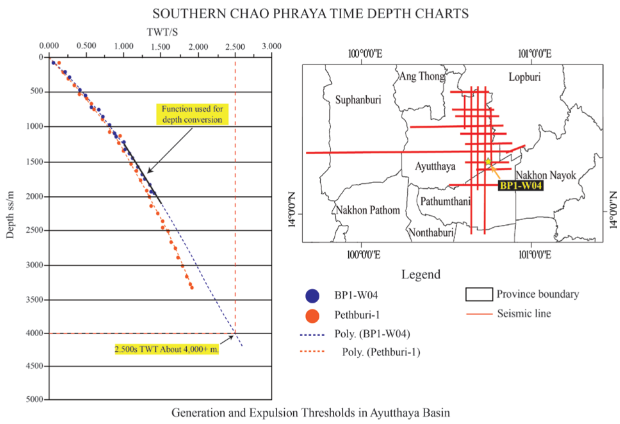

Figure 7 Time – Depth conversion chart of Southern Chao Phraya area (modified from O'leary, 1987)

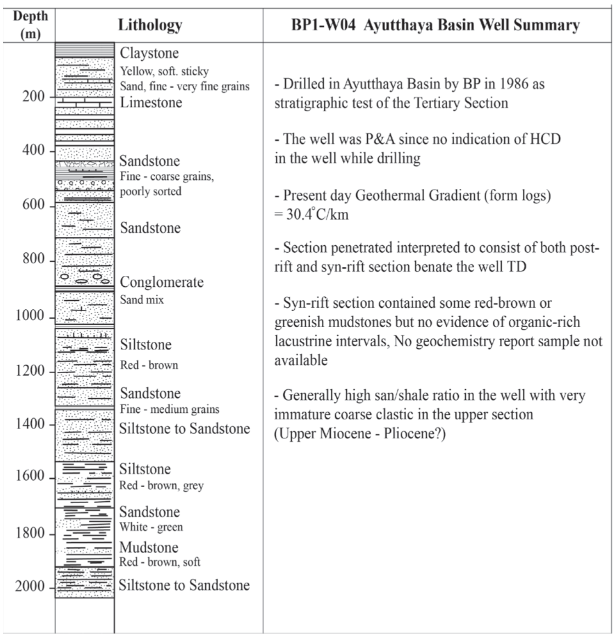

Figure 8 BP1 – W04 well report and stratigraphic column (Modified from O'leary, 1987)

4.3 Structural Reconstruction

Structural Reconstruction method was done in the evolution and development of deformation events in the basin. This study used Midland Valley Move® software 2017 in balancing technique to restoration section.

After reconstruction, we can analyze the extension rate in each polygon. It refers to the length of extension in the basin at that time which calculated by;

$$\beta = L / L_0$$

When; β is stretching factor
L is the length after deformation and sediment deposition
L_0 is the length before deformation and sediment deposition

While; β > 1 referred to the basin which has the extensional system
β < 1 referred to the basin which has the compressional system

This study will focus on the displacement of basin or basement and subsidence rate on each section.

5. RESULT

The result of the study can be subdivided into seismic stratigraphy and structural interpretation. The seismic stratigraphy is interpreted by using 2–D seismic data and well report. For the structural interpretation, structural reconstruction method is applied for the basin evolution and stretching factor.

5.1 Seismic interpretation

The seismic interpretation can be described the seismic character of each unit and combine with well data where located near to AY-093 section as shown in Figure 9 referred to the type of sedimentation in each unit. Based on the 2–D seismic data, the seven rock units can be determined and described in terms of seismic character and generated to time structural map (Fig 10).

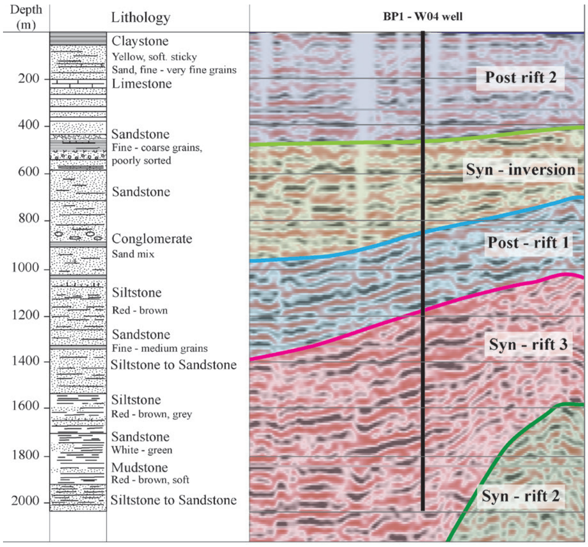

Figure 9 Seismic stratigraphic in the Ayutthaya Basin correlates with AY-093 section and BP1-W04 well report (Modified from BP1-W04 well report, 1987)

(1) Pre-rift unit

The Pre–rift unit or basement can be described with an antiform structure with high amplitude. This unit is characterized by wavy and discontinues reflectors. The western and eastern parts of basin have a structural high of this unit, but the west is higher indicated the basin geometry which the North – South trending of half graben basin.

(2) Syn-rift 1 unit

The Syn-rift 1 unit is characterized by continues reflectors, which covers the Pre-rift unit. High amplitude and continueous seismic reflector is boundary of the Pre-rift and Syn-rift 1 unit which is an unconformity. The seismic character of this unit presents in discontinuous of low seismic reflector and wedge shape with high dip to a major normal fault. This unit has thickness approximately 100 – 1200 meters and missing in some section.

(3) Syn-rift 2 unit

The Syn-rift 2 unit is separated from the Syn-rift 1 unit by high amplitude and continueous seismic reflector. It has also same character the Syn-rift 1 unit, but this unit shows slightly continuous reflector and low amplitude in the lower part to medium amplitude in the upper part. There is approximately 600 – 800 meters thick.

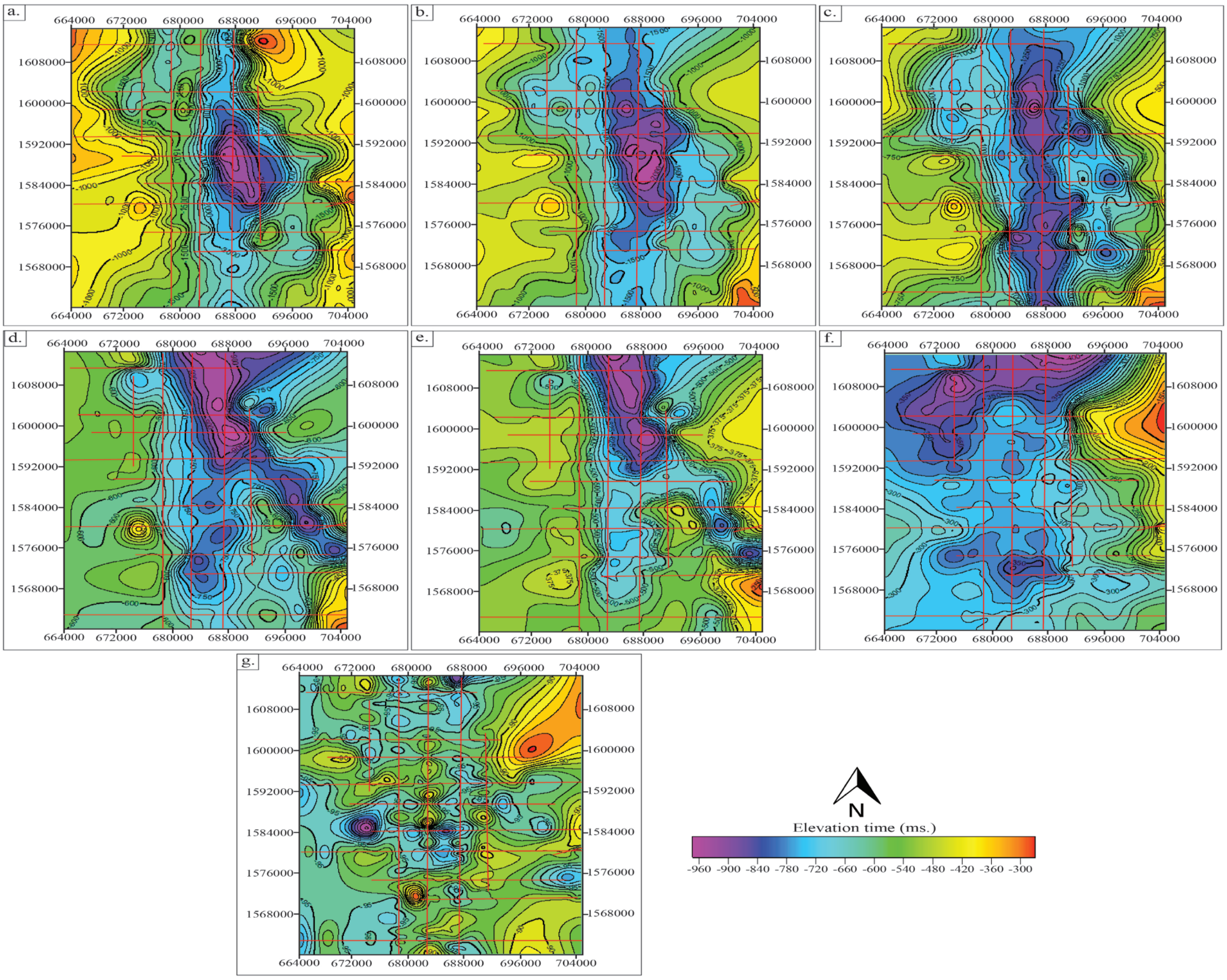

Figure 10 Time structural map of (a.) Top Pre-rift, (b.) Top Syn-rift 1, (c.) Top Syn-rift 2, (d.) Top Syn-rift 3, (e) Top Post-rift 1, (f.) Top Inversion, (g.) Top Post-rift 2.

(4) Syn-rift 3 unit

The Syn-rift 3 unit is bounded from the Syn-rift 2 unit by high amplitude and continue seismic reflector. This unit shows moderately continuous reflector with wedge shape and medium amplitude in the lower part to high amplitude in the upper part. The reflector is low to flat dip. Antiform is presented near the major fault in some section. This unit has approximately 300 – 1200 thick.

(5) Post-rift 1 unit

The Post-rift 1 unit is divided from the Syn-rift 3 unit by continuous and high amplitude. This unit is strongly continuous reflector with medium to high amplitude. The thickness is around 250 – 300 meters and fairly equal in all section. The reflector shows slight dip to flat reflector.

(6) Inversion unit

The Syn-inversion unit is distinguished by wedge shape and some truncation onto the Post-rift 1 unit. This unit is continuous reflector with medium to high amplitude. The reflector is an obvious onlap to the Post-rift 1 unit in the lower part and flat reflector in the upper part. The harpoon structure is presented in some section which is the antiform structure. This unit has 100 – 500 meters thick.

(7) Post-rift 2 unit

The Post-rift 2 unit is the youngest unit of this area which is a continuous seismic reflector. This unit is very flat package with medium to high amplitude. There is around 300 – 800 meters thick of sediment.

5.2 Structural interpretation

(1) Major normal fault

Major normal faults are westward dipping with large displacement approximately 20 – 100 meters. These faults bound the basin and control the main structural style and are mostly located in the center to eastern part of the basin. The normal fault is a domino faulting style in westward dipping and gathers in the deeper part as a listric normal fault.

(2) Basin character

The basin character of Ayutthaya Basin can be determined by the basement rock unit as shown the structural map of top basement horizon or Pre-rift unit. According to Figure 10, the structural map of basement has a deepest part or depocenter in the center of basin which is North – South trend. This basin has a 150 – 2500 meters depth. After sedimentation, the depocenter is changed into the northward due to the basin evolution and tectonic activity.

5.3 Seismic stratigraphy

After seismic and structural interpretations, we can generate seismic stratigraphy from the seismic character and structural vents. The seismic stratigraphy can be shown in Figure 11 which is the East – West section of AY-031.

5.4 Structural reconstruction

According to the result of seismic interpretation, the structural balancing is shown in AY-031 (Fig 12), AY-093, AY-001-3 and AY-181. After reconstruction, the result can be shown in the stretching factors (β) that related to how long the basin extended (Table 2) and the subsidence rate of each section.

Table 2
The seismic horizons and their color lines

Section	L (m.)	L0 (m.)	β
AY-011	28789.90	24051.30	1.197
AY-031	27092.60	21543.10	1.257
AY-093	26853.60	22689.30	1.184
AY-001-3	29855.20	25090.90	1.190
AY-181	30959.80	28521.70	1.085

The stretching factor of Ayutthaya Basin is approximately 1.18 that refers to the extensional system. However, the extension factor shows the difference of value in each section that may have another factor controlling during rifting. Based on the extension factor, it is decreasing from bottom to top part of each section. This is probably caused of oblique extension and strike – slip movement and then it was slower until the stretching factor became 1.00 that maybe a stable stage in present day.

6. Discussion

Due to the seismic interpretation and structural reconstruction of the Ayutthaya Basin, the results can be described in terms of basin evolution and related to regional tectonic event.

6.1 Tectonic evolution of Ayutthaya Basin

The evolution of the Ayutthaya Basin can be divided into four phases, which are extensional phase, subsidence phase, inversion phase and regional subsidence phase as shown in Figure 13.

(1) Extensional phase

The basin geometry is likely to be affected by pre–existing structure in NW – SE trend of oblique rifting (McClay, et al., 2004). During Late Oligocene? – Middle Miocene, the Syn-rift units were developed in alluvial fan deposits. Based on the structural reconstruction, the western part of Ayutthaya basin is a high elevation of limestone mountain while the eastern part has a low elevation, so the sedimentary source came from the west and deposited in Syn-rift 1 unit. During Early to Middle Miocene, the Ayutthaya Basin also continuously extended which result in the Syn-rift 2 and 3 being deposited in the basin. In this case, the normal fault in center and eastern parts occurred (Figure 13a) while the basement or Pre-rift unit may completely subside as shown in unconformities between Syn-rift 1, 2 and 3.

(2) Subsidence phase

After extensional phase, the basin was slowly extended and stopped in Middle Miocene. Subsidence phase or sagging began which fresh water lagoon environment occurred. The sedimentation is deposited in Post-rift 1 unit as shown the onlap reflector to Syn-rift units (Figure 13b). This phase is a short period of subsidence due to the Post-rift unit is not too much thick.

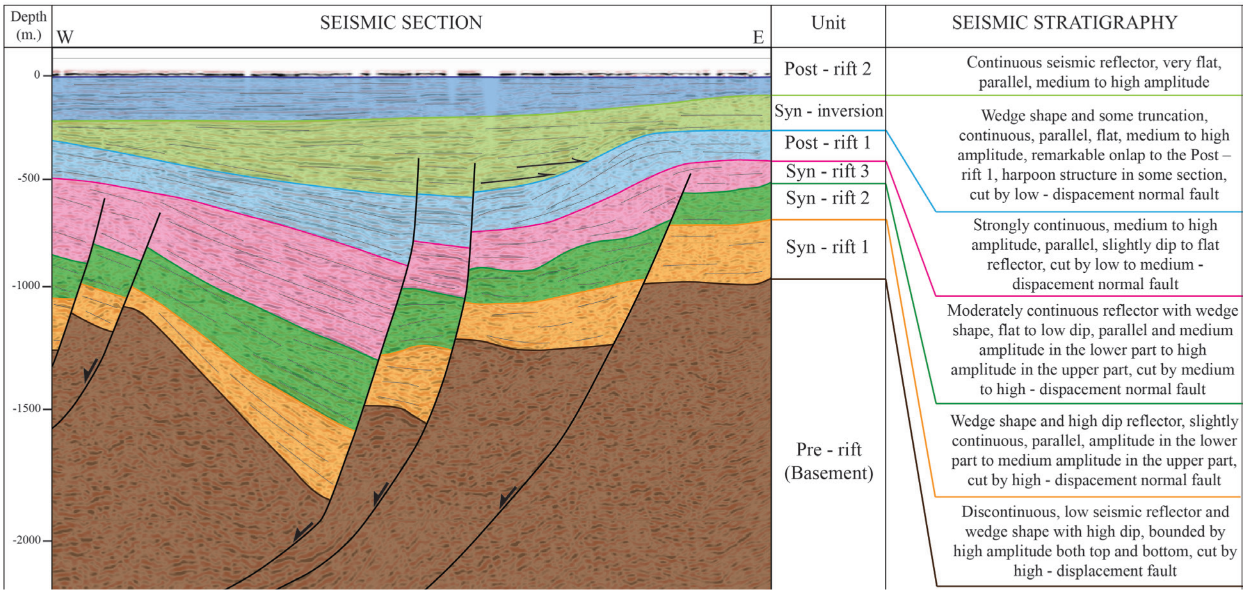

Figure 11 Seismic stratigraphy of AY-031 section shows the result of seismic interpretation and their seismic characters

(3) Local inversion phase

During Middle to Late Miocene, the Ayutthaya Basin was affected by compression force in Northwestern trend (NNW). This situation may be caused by the effect of Mae Ping fault which the fault movement may not be the same direction in all period. In addition, the harpoon structure can be found in some section, so there is a randomly inversion structure supporting with stretching factor is around 1.18, but some section is 1.01. In this case, there is some erosion caused of uplift the Post-rift 1 unit above the surface. The depositional environment in this phase is fluvial system (Figure 13c).

(4) Regional subsidence phase

The compression period ended in Pliocene and the basin has subsided until Recent. After inversion phase, it changed the depositional environment from lagoon to fluvial system (Figure 13d). According to the thickness map and structural reconstruction, the sedimentary sections were deposited in Post-rift 2 unit with westward thickening so that the western part may have more subsidence than the eastern part. The sediment has been supplied by fluvial process from North to South which is Chao Phraya River.

The tectonic evolution of the Ayutthaya Basin can be support by the regional tectonic that referred to the tectonic events of Thailand during Indosinian Orogeny (Morley, 2015) in Mesozoic until recent (Fig 14 and 15). Therefore, this evolution is reasonable that associated with the regional tectonic of Thailand. The basin evolution of this study is also agreeable with the previous studies by Koomchay (2015) and Jirarachwaro (2016) that suggest four phases of the evolution.

6.2 Stretching factor of nearby basin comparison

The stretching factor and extension rate of Ayutthaya Basin are approximately 1.18 athat refers to the extensional system.

The extension trend is located in East – West, but the North – South trend also slightly extend. This value is suitable when compared with other rift basins (Table 3). Based on the structural reconstruction, the Ayutthaya Basin is similar Bohai Bay Basin in terms of the basin evolution that strike-slip fault related to control the basin development by oblique extension (Dong – Xiao Feng and Fu Ye., 2017). The Bohai Bay Basin is a transtensional basin that was formed by reactivation of basement during Cenozoic. The stretching factor of this basin is 19 % in average with 1,450 m. thickness of sediment. The extensional in this basin was controlled by an oblique extension stress of mainly strike – slip faults. Hence, the Ayutthya Basin may have the extension phase with

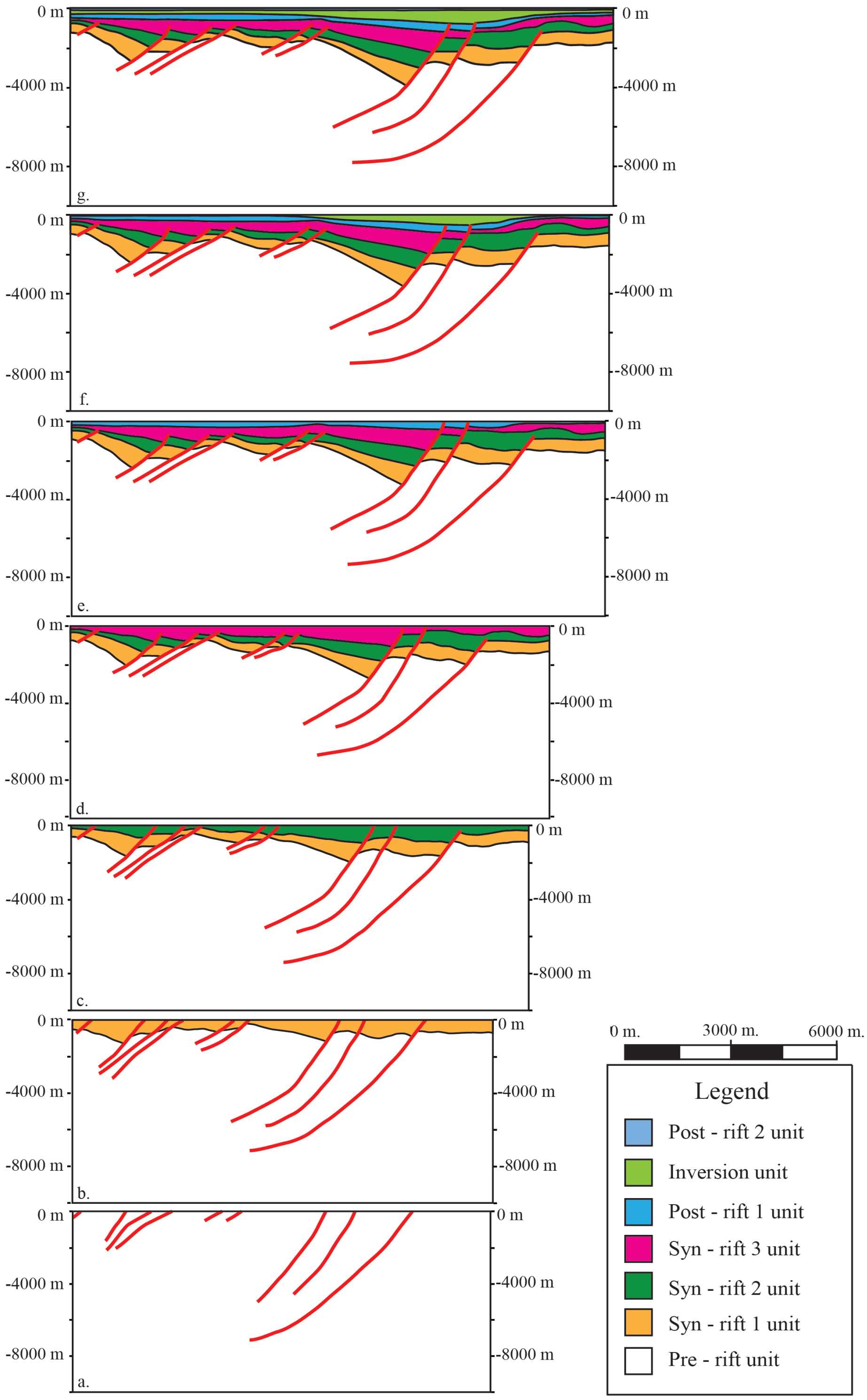

Figure 12 The structural evolution of Ayutthaya Basin in AY-031 section; looking North which (a.) is a present day structure, (b.) after Post-rift 2 unit decompaction, (c.) after Inversion unit decompaction, (d.) after Post-rift 1 unit decompaction, (e.) after Syn-rift 3 unit decompaction, (f.) after Syn-rift 2 unit decompaction, and (g.) Basement restoration.

oblique extension that might be affected by major strike – slip fault.

6.3 The effect of Mae Ping fault in Ayutthaya Basin

The relationship between Mae Ping fault and Ayutthaya Basin is located in the Northern

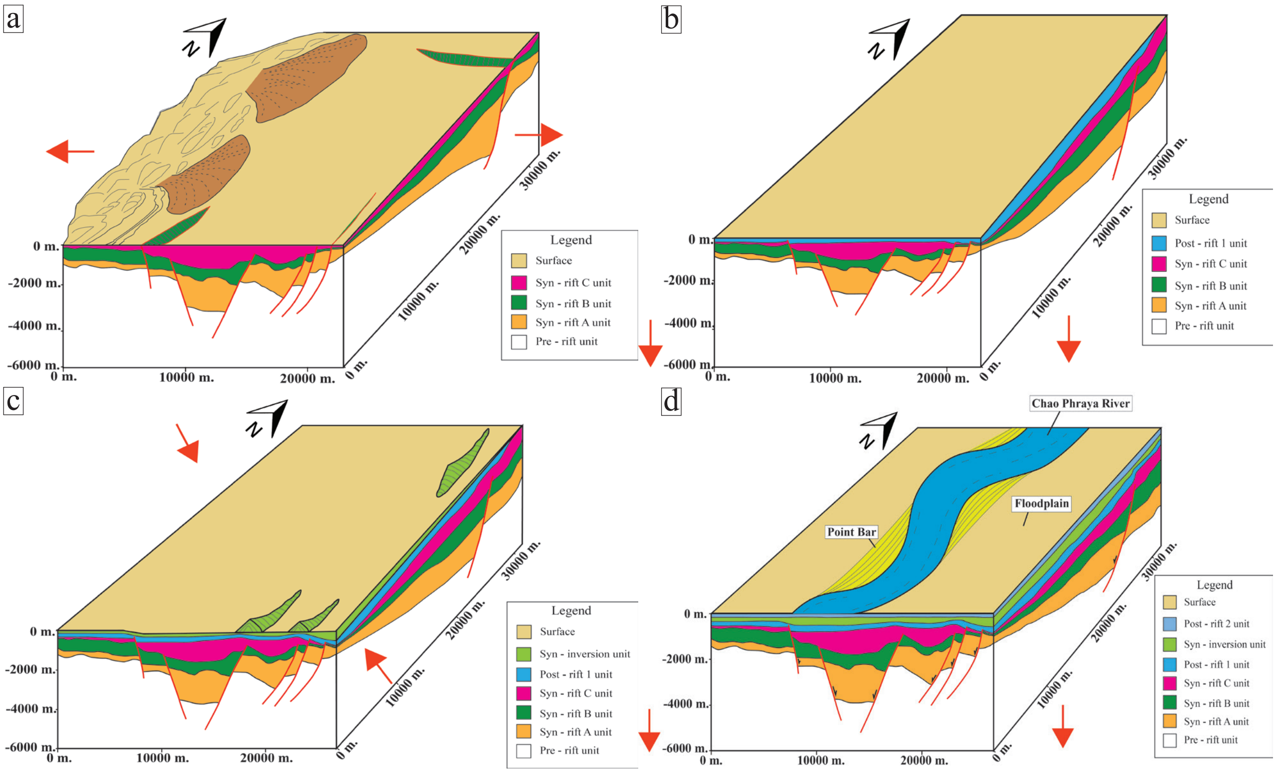

Figure 13 The Ayutthaya Basin evolution of (a) The model of extensional phase during Late Oligocene? – Middle Miocene, (b) The model of subsidence phase during Middle Miocene, (c) The model of local inversion phase during Middle Miocene – Late Miocene was effected by NW – SE compression, randomly inversion or harpoon structure was developed, and (d) The model of regional subsidence during Pliocene – Recent.

Table 3 Comparison the stretching factor with other basin

The East African Rift	1.10 – 1.40	Ebinger (1989), Hendrie et al. (1994)
The North Sea	1.15 – 1.40	Lippard and Liu (1992)
The Pattani Basin	1.20 – 1.30	Anun (1993)
The Songkhla and Western Basins	1.10 – 1.40	Chanida and Ian (2017)
Bohai Bay Basin	1.10 – 1.40	Dong –Xiao Feng and Fu Ye (2017)

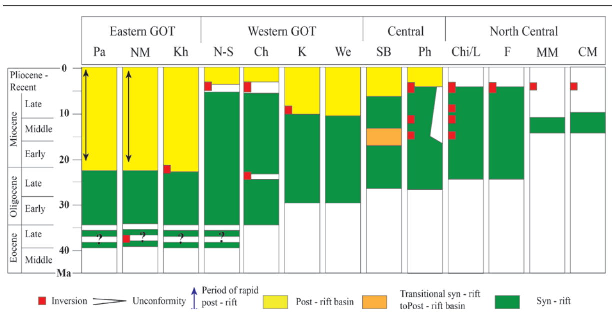

Figure 14 Generalize chart of Cenozoic structural activity in key rift basin in Thailand. (Modified from Morley, 2015); Pa = Pattani basin, NM = North Malay basin, Kh = Khmer basin, N-S = Nakhorn and Songkhla basins, Ch = Chumphon basin, K = Kra basin, We = Western basin, SB = Suphanburi basin, Ph = Phisanulok basin, Ay = Ayutthaya basin (this study), Chi/L = Li basin, F = Fang basin, MM = Mae Moh basin, and CM = Chiang Mai basin.

part of the basin. The study of Smith et al. (2007) shown that Mae Ping fault zone is a sinistral strike-slip fault and the Ayutthaya Basin also located on that fault zone. According to magnetic survey of the Central Plain of Thailand, the structural style of the Ayutthaya Basin has a rotation of normal fault from N – S to NW – SE which is the same direction of the Mae Ping Fault. Base on the seismic data, there is no evidence of displacement of NW – SE fault. Hence, the interpretation can describe that the Ayutthya Basin is controlled by a pre-existing fabrics and the normal fault is controlled by this structure. However the pre-existing area is a weak zone, the normal fault can be rotated from N – S trend to NW – SE trend. In addition, the Mae Ping fault may have resulted in inversion due to the changing of movement from sinistral to dextral movement in Middle Miocene. Therefore, inversion structures are randomly occurring due to the NNW – SSE compression and is usually found in Northern part of the basin.

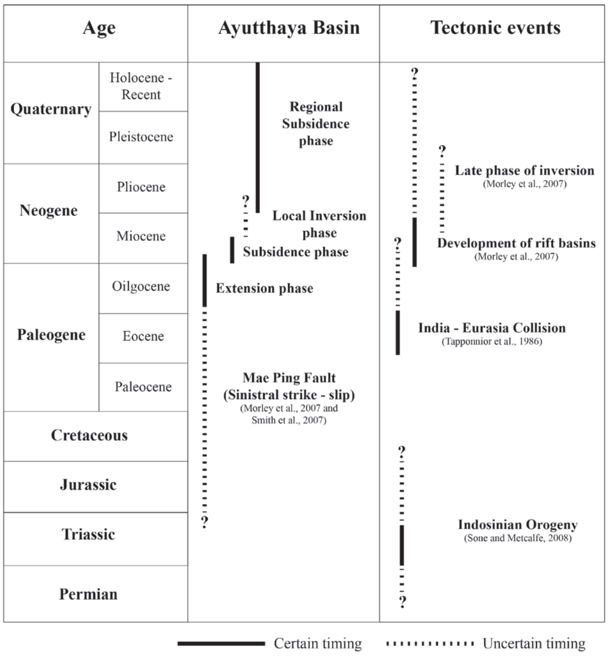

Figure 15 Comparative diagrams of the Ayutthaya Basin evolution (this study) and the regional tectonic evolution. (Modified from Koomchay, 2015)

6.4 Suphanburi Basin structural style comparison

Suphanburi Basin is located approximately 70 kilometers in the West of the Ayutthaya Basin. The basin geometry is also half–graben in North – South trends similar to the Ayutthaya Basin. The main structure is eastward dipping normal fault that is opposite to the main structure of the Ayutthaya Basin (O' Leary and Hill, 1989, and Seusuthya and Morley, 2004). Both Ayutthaya and Suphanburi Basins have 2 – 4 kilometers thickness of sediments. Due to the relationship between Suphanburi Basin and Mae Ping Fault, there is no evidence of major inversion and strike – slip tectonics that caused the opening of the basin as the Ayutthaya Basin. The extensional reactivating of pre – existing fabric in N – S, NE – SW and NW – SE controlled the basin geometry (Buayai, 2005). In addition, Suphanburi Basin has a petroleum potential where the reservoir mostly located in unit D. On the other hand, the Ayutthaya basin has no evidence of hydrocarbon both in exploration well and seismic data. In this case, the possibly reason is the igneous intrusion in the Suphanburi Basin. According to the Pisutha – Arnond's study in 2008, the source rocks were indicated in BP1–1 well but the thermal maturity modeling is difficult. The best model shown heat flow history is 110o C at 1,900 m. and began around 10 Ma that the heat came from sill intrusion. Dolerite sill found in this well and also correlated to high reflector in seismic data. Therefore, the dolerite sill could have been an evidence of magmatic bodies in Kamphangsaen Basin and increased heat flow and thermal maturity of kerogen to generate hydrocarbons. As a result, hydrocarbonshave been generated as young as 4 Ma to present day.

6.5 Petroleum system and prospect potential

The main problem of this study is why the Ayutthaya Basin is considered as a low hydrocarbon potential. Based on the seismic interpretation and structureal reconstruction, the basin geometry shows the Ayutthaya Basin is a shallow basin. Unfotunately, the Ayutthaya Basin has no intrusion evidence in the basin. In addition, It could be the answer of no hydrocarbon generation in this basin. Moreover, some petroleum element might not be presented that is an important for petroleum system. Due to the well data, source rock, which has an organic-rich, has not be proved and presented in the well. Moreover, fine-grain clastic rock or cap rock also doest not show in the lithology log sugessing there may not have seal in this basin.

Due to the petroleum system in Suphanburi Basin, the sedimentary deposition of the Ayutthaya Basin might be similar with the Suphanburi Basin because it occurred close to the same time. Therefore, if the Ayutthaya Basin has a petroleum potential, the petroleum system is shown in Figure 16 The possibility source potential is located in the Syn-rift 1 unit of this study which is a lacustrine shale. The reservoir may have a potential in Syn-rift C and Post-rift 1 units which is an alluvial fan/ fluvial sandstone reservoir and also in Syn-inversion unit which has fluvial sandstone reservoir. Lacustrine mudstone in Post-rift 1 and 2 Units can be a good seal. However, there are uncertain of this basin that it has no source rock potential or no hydrocarbon generation and reservoir data in this basin.

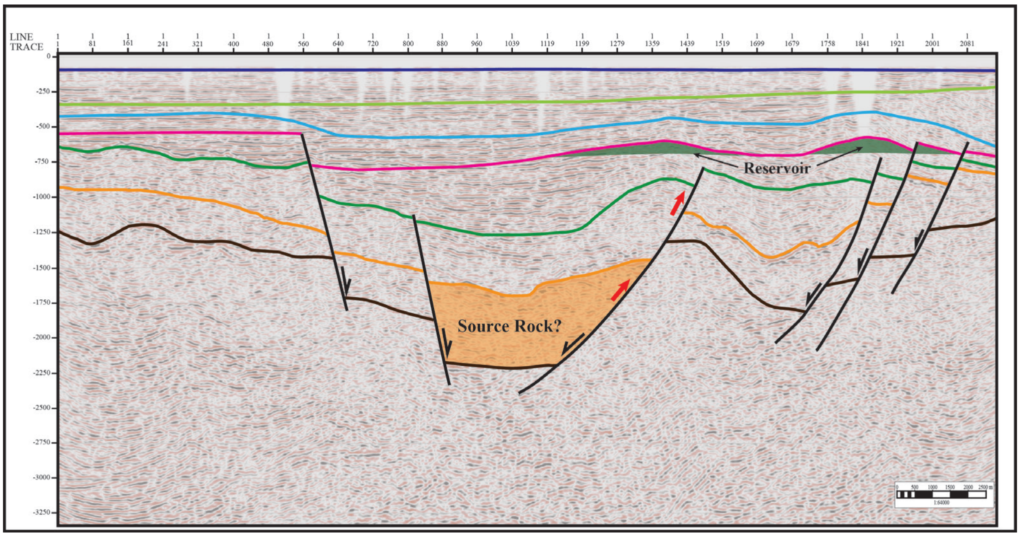

Figure 16 The possible petroleum play of the Ayutthaya Basin in AY-093 section while source rock and reservoir are Syn-rift 1 and 3 units respectively on the four way dipping closure trap.

7. Conclusions

The Ayutthaya Basin is the Cenozoic basin that has a North – South trend and is located in lower central plain of Thailand. The basin geometry is controlled by pre-existing structures. It has westward dipping normal fault form the half-graben basin. The major faults are North – South orientation fault in Cenozoic period can be used to divide into seven units by using seismic characters and well report including; Pre-rift, Syn-rift1, 2, 3, Post-rift 1,Syn-inversion, and Post-rift 2 units.

There are 4 phases of basin evolution based on seismic interpretation and structural reconstruction from older to younger events following;

(1) Extensional phase in Late Oligocene? – Early Miocene.

(2) Subsidence phase and sagging in Middle Miocene.

(3) Local inversion phase in Middle – Late Miocene which was affected by Mae Ping fault as shown in randomly formed harpoon structure in some area.

(4) Regional subsidence from Pliocene – Recent.

According to the basin evolution and reconstruction, the stretching factor (β) is approximately 1.18 that resembles to Bohai Bay Basin, China the Ayutthaya Basin due to the randomly which is a transtensional basin. Therefore, Mae Ping fault affected to inversion and basin geometry from the changing of strike – slip direction supporting with magnetic survey. The Ayutthaya Basin is similar to Suphanburi Basin, but it is different in the major normal fault dipping trend and effect of Mae Ping Fault. The possible reason of no petroleum potential in the Ayutthaya Basin is a lack of hydrocarbon generation which means there were no source of heat to extract kerogen to hydrocarbon.

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