CHAPTER V

DEPOSITIONAL ENVIRONMENT

The detailed lithostratigraphy of some Tertiary sediments of the Mae Moh basin earlier defined in this study serves as a fundamental basis for the analysis of lithofacies. The lithofacies used in the present investigation covers four main aspects, notably, lithology, geometry, sedimentary structure, and fossils. Sedimentary facies is defined as any areally restricted part of a designated stratigraphic unit which exhibits characters significantly different from those of other parts of the unit. The rock record of any sedimentary environment, including both physical and organic characters, is designated by the term "lithofacies" (Moore, 1949). A group of related lithofacies or facies association is used to represent related depositional environments or depositional system.

In the foregoing Chapter, discussion will be focussing upon various aspects of sedimentary basin analysis, namely, basin configuration and basin formation, lithofacies analysis, reconstruction of depositional environment, and tectonic sedimentation.

5.1 Configuration and formation of Mae Moh basin

The Mae Moh Tertiary basin is roughly triangular elongate trending in NNE/SSW direction. Evidences from seismic survey and exploration drilling reveal that the Mae Moh basin consists of four separated sub-basins, namely, main sub-basin, northern sub-basin, western sub-basin, and southern sub-basin. The main sub-basin, northern sub-basin and western sub-basin are separated by the structural high. The study area, covering approximately 32 square kilometres, is located essentially in the main sub-basin.

The Mae Moh basin is believed to be a fault-bound basin originated from the late Cretaceous-early Tertiary (?) block-faulting. The western part of the basin is marked by the NNE/SSW fault, whereas the eastern part of the basin is probably marked by N/S fault. The Mae Moh basin is, therefore, formed by the graben structure of non-parallel faults opening southwardly. This structural-controlled basin is part of the Sukhothai fold-belt which was formed by the late Triassic collision of Shan-Thai, Indochina and South China microcontinents. In post Middle to Late Miocene or Late Tertiary time, a tensional tectonic regime developed and a system of nearly north-south trending normal fault appeared which was followed by the accumulation of mainly red color fine-grained clastic rocks of the C-Formation. There nearly north-south trends influenced the present structural synclinal basin. These faults also created the approximate east-west extension of the present day Mae Moh basin.

5.2 Lithofacies analysis

On the basis of lithofacies analysis, the Mae Moh basin under the present study consists of 3 facies associations, namely, facies association A, B, and C in ascending order. These facies-association have been subdivided into lithofacies and all of them are used correspondent with the name of the proposed lithostratigraphic unit.

5.2.1 Facies association A

The lowest Tertiary sedimentary sequence of Mae Moh basin which lies unconformably on the pre-Tertiary basement rocks is the A-Formation. The lower part of the A-Formation, A-1 Member, of 9-52 metres thick is characterized by at least 8 cycles of fining-upward sequence of weakly consolidated of conglomerate or conglomeratic sandstone to clayey siltstone with both erosional surface and abrupt change in grain-size at the base of each cycle, closed work structure, color mottling, and rare gastropod fragments. This lower sequence is called "lithofacies A-1". The geometry of this lithofacies can not be definitely defined because of limited subsurface information. The upper part of the A-Formation, A-2 Member, is also characterized at least 6 cycles of fining-upward sequence of weakly consolidated of conglomeratic sandstone or sandstone to claystone with rare gastropod fragments of totally upto 88 metres thick. The ratio between fine-grained clastics and coarse-grained clastics is high. The uppermost part of this sequence is marked by thin coal bands. The parting within coal bands is calcareous silty claystone with common gastropods, intraformational conglomerate and lignite flake. This upper sequence is called "lithofacies A-2". This lithofacies is relatively widely distributed than lithofacies A-1 and thickening in the west-central part (Table A-2.1 in Appendix 2). The facies association of the A-Formation is summarized and presented in Table 5.2.1a.

5.2.2 Facies association B

Conformably overlying the A-Formation is the B-Formation

Table 5.2.1a The salient characteristics of facies association A.

Lithostratigraphy						Lithofacies	
Group	Formation	Member	Graphic	Sedimentary Structure	Description		
	A-Formation	A-2		mottle, calcrete, bioturbation, bonded, intraclasts, fining upward, load structure	semi-cons. rocks : alternation of fine-to c.-g. clastic rocks, varicolored w.LGT or highly carb. at the top, gastropod. (-88 m.)	lithofacies A-2	Facies Association A
		A-1		fining upward, lag deposit, closed work, mottle	semi-cons. rocks : m. to c.-g. clastic rocks, varicolored, gastropod. (9-52 m.)	lithofacies A-1	

with maximum thickness upto 560 metres. The B-Formation is further subdivided into 6 members which are corresponding to 6 lithofacies of facies-association B.

The lower part of the B-Formation, B-1 Member, is characterized by thin-to medium-bedded calcareous claystone and calcareous silty claystone with carbonaceous claystone in the lower part; laminated to thin bedded calcareous claystone and carbonaceous claystone (slightly calcareous) in the upper part of the sequence. Fish fragments are common throughout the sequence while gastropod of Viviparus sp., Melanoides sp., ostracod, bioturbation, calcareous lentil structure, lignite flake and intraformational conglomerate are dominantly present in place. It is noted that there are thin coal seam present in the upper one-third of the sequence. This thin coal seam is widely distributed throughout the study area. This sequence is called "lithofacies B-1" (see Table 5.2.2a). The geometry of this lithofacies is sag-shaped. It is thickening in the central part of the study area (LM 2963S) and thinning towards the margins.

The B-2 Member lies conformably on the B-1 Member with gradational contact. It is characterized by thick coal bands and partings. At least 4 major sedimentary cycles of coal is recorded which can be further subdivided in terms of member into 4 members. Coal seam with small amount of partings is present in the central part whereas the southern and northern parts are represented by dominant partings. The parting in the central area is characterized by highly calcareous claystone whereas the southern and northern margins some silt-sized quartz are represented. Fresh-water fossils

Table 5.2.2a The salient characteristics of facies association B.

Lithostratigraphy						Lithofacies	
Group	Formation	Member	Graphic	Sedimentary Structure	Description		
Mae Moh Group	B - Formation	B - 6		bioturbation, intraclasts, rootlet, lam. to thin, wavy bedded, load structure, local unconformity	semi - cons. rocks ; alternation of highly calc. gy CLST & silty CLST, banded LGT, w some LST, intra. fm. cgl., SS & Cgl., A. gastropod, ostracod & fish frag. (15 - 65 m)	lithofacies B - 6	Facies Association B
		B - 5		bioturbation, intraclasts, lam. to thin, local unconformity	gy silty CLST, highly calc. w intra. fm. cgl. gastropod, ostracod & fish in - upper & lower parts; gy CLST, highly calc. w fish frag. in mid part. (60 - 100 m)	lithofacies B - 5	
		B - 4		bioturbation, rootlet, thin to thick, banded, lentil, hard band, wh. calc. spot	LGT w partings of highly calc. gy CLST & silty CLST, siliceous hard band, foss. of Planorbis sp. Viviparus sp., Melanoides sp., fish. frag., mastodon, turtle, amphibian. Partings are predominant in northern & southern parts. (20 - 35 m, - 80 m)	lithofacies B - 4	
		B - 3		lam. to thin, bioturbation, load structure	gy CLST, highly calc. w LGT banded in upper part, C. fish frag & ostracod. (15 - 38 m)	lithofacies B - 3	
		B - 2		bioturbation, rootlet, thin to thick, banded, lentil, wh. calc. spot	LGT w partings of highly calc. gy CLST & silty CLST, Viviparus sp., fish. frag. Partings are predominant in northern & southern parts. (10 - 30 m, - 60 m)	lithofacies B - 2	
		B - 1		lam. to thin, intraclasts, bioturbation, thin to m.	gy CLST, highly calc. w Viviparus sp. beds in upper part, LGT banded in mid part w gastropod, fish, intra. fm. cgl.; C. fish frag. & py. (38 - 217 m)	lithofacies B - 1	

of fish fragments, Viviparus sp., and sedimentary structure of bioturbation, lentil structure and white calcareous spot are common. This sequence is called "lithofacies B-2 (Table 5.2.2a). Coal seam of this lithofacies is more splitting in the northern margin than in the southern margin with thickness upto 60 metres in the former one. In the central area, the seam is thickening toward the eastern and southeastern margins, and thinning westwardly. However, the thickness of good quality coal seam is rather consistent and persistent for several hundred metres in the longitudinal direction.

The next, B-3 Member, lies conformably on the B-2 Member with generally sharp contact. It is characterized by laminated to thin-bedded clacareous claystone, calcareous silty claystone and slightly calcareous carbonaceous claystone (Figure 3.3.3a), common gastropods, fish fragments, ostracod, lignite flake, bioturbation, intraclasts, and abundant micro-slickenside. This sequence is called "lithofacies B-3" (Table 5.2.2a). The lithology of this lithofacies is fairly consistent throughout the study area. It is thickening towards the southeastern and eastern margins and gradually thinning towards the western, southern and northern margins.

The B-4 Member, upper major coal seam, lies conformably on the B-3 Member with gradational contact. It is characterized by at least 4 major sedimentary cycles of coal seam. The lithology is similar to the lithofacies B-2, coal seam with small amount of partings present in the central area thickening eastwardly and southeastwardly upto 30 metres thick. Coal seam is splitting towards northern and southern margins, the latter one shows higher degree of splitting than the former one with thickness upto 80 metres. This sequence is called "lithofacies B-4" (Table 5.2.2 a). Fresh-water fossils of Planorbis sp., Viviparus sp., Melanoides sp., fish fragments, amphibian fragments are common. Besides, the mastodon and turtle of fresh-water origin also reported from this lithofacies.

The adjacent member, B-5 Member, lies conformably on the B-4 Member with sharp contact. It is characterized by laminated to thin - bedded calcareous claystone, calcareous silty claystone and carbonaceous claystone with fresh-water gastropods of Viviparus sp., Melanoides sp., ostracod, fish fragments, lignite flake (plant debris) and rootlet. The bioturbation, load structure and intraformational conglomerate are common in the upper and lower parts of the sequence, whereas they are only sporadically present in the middle part. The lithology of this member is rather consistent throughout the study area except in the far southern area where some beds of sandstone and conglomerate are present. This sequence is called "lithofacies B-5" (Figure 5.2.2 a). The geometry of this lithofacies is tabular-shaped (krynine, 1948). Besides, it is thickening in the southeastern and northern margins and gradually thinning towards the western and southern margins (Figure 3.3.5 d).

The uppermost sequence of the B- Formation is the B-6 Member. It lies conformably on the B-5 Member with gradalional contact. It is characterized by alternation of weakly consolidated of thin to thick bands lignite, impure coal, calcareous claystone, calcareous silty claystone with some beds of micrite. However, in the far southern area the sequence contains some beds of sandstone and conglomerate while coal appears as trace. Fresh-water fossils of Melanoides sp., Viviparus sp., ostracod, fish fragments and plant debris are common to abundant. Bioturbation, intraformational conglomerate, load structure and pull-apart structure are also common. This sequence is called "lithofacies B-6" (Figure 5.2.2 a). The geometry of this lithofacies is mainly confined within the central zone elongated parallel to the shape of the basin or study area. It is tabular shaped and slightly thickening in the northern part of upto 70 metres thick and gradually thinning southwardly.

5.2.3 Facies association C

The uppermost lithostratigraphic unit of the Mae Moh Group is the C-Formation. It overlies partly conformably and partly unconformably the B-Formation. The C-Formation consists of 3 members, namely, C-1, C-2 and C-3 Members which are renamed in lithofacies as facies association C, lithofacies C-1 lithofacies C-2 and lithofacies C-3, respectively.

The lowermost sequence of the C-Formation, C-1 Member, is characterized by semiconsolidated, variegated-color silty claystone and claystone with color mottling, calcrete, gypsum crystals and gray calcareous claystone fragments. However, the lower part of the sequence is represented by interbedding of gray and red color claystone / silty claystone. Plant remains and rootlet are also common in the gray claystone. This sequence is called "lithofacies C-1" (Figure 5.2.3. a). The geometry of this lithofacies is mainly confined within the two major fault-zones (Figure 3.4.1 c) with thickness upto 200 metres. It is, however, shoestring shaped thickening in the central area up to 200 metres, slightly thinning

Table 5.2.3a The salient characteristics of facies association C.

Lithostratigraphy						Lithofacies	
Group	Formation	Member	Graphic	Sedimentary Structure	Description		
	C-Formation	C-3		mottle, calcrete, intraclasts, rootlet	semi-cons. rocks : rd silty CLST & CLST in lower part, gy col. w carb. matter & gastropods in upper part. (- 190 m)	lithofacies C-3	Facies Association C
	C-Formation	C-2		fining upward, mottle, intraclasts, iron concretion	semi-cons. rocks : m.- to c.-g. clastic rocks in upper & lower parts, fine-g. in mid part, rd col., gyp. xal (2 - 93 m)	lithofacies C-2	Facies Association C
	C-Formation	C-1		mottle, calcrete, intraclasts, rootlet, intb.	semi-cons. rocks : fine-g. clastic rocks rd col. in upper part, alternation of rd & gy col. in lower part, gyp. xal (4 - 277 m)	lithofacies C-1	Facies Association C

towards northern and southern margins.

The middle sequence of the C-Formation, C-2 Member, is characterized by semiconsolidated claystone, silty claystone, siltstone, sandstone and conglomerate with some fining-upward sequence, color mottling, gray claystone fragment, plant remains, gypsum crystals and calcrete. This sequence is called "lithofacies C-2" (Figure 5.2.3a). The geometry of this lithofacies is also confined within the two major fault-zone (Figure 3.4.2a). It is prismatic shaped thickening in the central area and gradually thinning southwardly.

The uppermost sequence of the C-Formation, C-3 Member, is characterized by semiconsolidated, red, brown and yellow color claystone and silty claystone with some siltstone and sandstone, color mottling, calcrete and gray claystone fragments. However, in the upper part of the sequence the semiconsolidated gray claystone, carbonaceous claystone and impure coal are present locally. Rootlet, gypsum crystals of needle-shaped, calcrete and color mottling are common. This sequence is called "lithofacies C-3". The geometry of the lithofacies C-3, is mainly confined within two major-fault zones(Figure 3.4.3a). This lithofacies is overlain unconformable by the Quaternary deposits.

5.3 Proposed Depositional Environment

5.3.1 Depositional environment of facies association A

The facies association-A consists of 2 lithofacies, namely, lithofacies A-1 and lithofacies A-2. The repeated characteristics of fining-upward sequences of lithofacies A-1 suggest that they were deposited under the fluvial environment (Allen, 1964, 1965; Walker, 1976; Selley, 1970;and Reading, 1978). The lithological characteristics of at least 8 cycles of fining-upward sequence of mostly coarse-grained clastics indicate that this lithofacies represents alluvium of braided river deposited in the high relief alluvial plain resulted from block-flaulting. Microscopically, the quartz grains of lithicarenite show mainly of monocrystalline with unit extinction indicating that they are derived from igneous body rather sedimentary or metamorphic rocks (Tucker, 1981). Although, the information of deep boreholes is limited, it can be concluded at this stage that the paleochannel should be located in the western part of the study area.

The upper part, lithofacies A-2, is characterized by at least 6 cycles of fining-upward sequence of mainly sands and clays of equal proportion. This lithofacies suggests that it was deposited in fluvial environment of meandering river type. Almost all cycles of meandering river end with the fine-grained clastic overbank deposits. Quartz grains of lithicarenite mainly show non-undulatory extinction indicating that they are derived from igneous origin. Some parts of this lithofacies appear as red silty claystone. The red silty claystone with some gray claystone fragments indicates that it should be deposited under oxidizing condition.

It is noted that the graben of Mae Moh basin was at first infilled with fluvial sediments of briaded river of lithofacies A-1 under the influence of high relief. Later on, the fluvial sedimentation had changed from braided river to meandering river of lithofacies A-2 as resulted from the changes of relief after deposition of lithofacies A-1. The change of relief is believed to be partially controlled by the topography of post-lithofacies A-1 sedimentarion. The proposed depositional model of facies association A is presented in Table 5.3.1a.

5.3.2 Depositional environment of facies association B

After the deposition of facies association A of more than 100 metres thick, the Mae Moh basin had been subsided. It is believed that the load of sediments of the facies association A plays an important role as a trigger mechanism for the reactivation of the block-faulting. This block-faulting is presumably the same one that produced the original graben of the Mae Moh basin.

The sedimentation in Mae Moh basin had continued after block-faulting under the lacustrine and/or swamp or marsh environment. This is indicated by the laminated to thin-bedded fine-grained clastic associations and coal seams of the facies association B of maximum thickness of 560 metres.

The lowest part of the facies association B, lithofacies B-1, is characterized by laminated calcareous gray claystone associated with thin coal band and fresh-water fossils, ie. fish fragments, gastropods etc. This suggests that they were deposited under the calcium-rich lacustrine environment (Reeves, 1968; Picard and High, 1972; Statch et al., 1975). The presence of thin coal

Table 5.3.1a The salient characteristics and interpretation with respect to the tectonic influence of the Mae Moh basin.

Lithofacies	Facies association	Lithology	Sedimentary Structure	Geometry	Fossils	Depositional environment		Major controlling factors: Subsidence: Basinal fault	Subsidence: Intrabasinal fault	Subsidence: loading	Silting-up
lithofacies C-3	Facies association C	silty claystone, claystone	color mottling, intraclasts rootlet	prismatic-shaped	rare fresh-water gastropod, plant remains	overbank	FLUVIAL				
lithofacies C-2	Facies association C	conglomerate or sandstone to claystone	fining-upward sequences, color mottling, intraclasts	prismatic-shaped	plant debris	meandering river	FLUVIAL				
lithofacies C-1	Facies association C	silty claystone, claystone	interbedding, color mottling variegated color, rootlet, intraclasts	prismatic-shaped shoestring shaped	plant debris	overbank	FLUVIAL				
lithofacies B-6	Facies association B	alternation of coal, calcareous claystone and silty claystone with micrite	bioturbation, intraclasts, load and pull-apart structure, lignite flake	sheet-like Tabular shaped	fresh-water gastropod, fish -fragments, ostracod plant	swamp/marsh, fresh-water shallow lake, with overbank	LACUSTRINE				
lithofacies B-5	Facies association B	calcareous claystone and silty claystone, carbonaceous claystone	lamination to thin bed, rootlet, bioturbation, intraclasts, lignite flake	sheet-like	fresh-water gastropods, fish-fragments, ostracod, mastodon	fresh-water lake	LACUSTRINE				
lithofacies B-4	Facies association B	coal, parting (calcareous claystone and silty claystone) siliceous hard band	band, seam splitting, lignite flake, bioturbation	sheet-like sag-shaped	fresh-water gastropod, fish -fragments, mastodon turtle	swamp/marsh	LACUSTRINE				
lithofacies B-3	Facies association B	calcareous claystone and silty claystone with thin coal band	lamination to thin bed, bioturbation, lignite flake, intraclasts	sheet-like Sag-shaped	fresh-water gastropods, fish fragments plant remain	fresh-water lake	LACUSTRINE				
lithofacies B-2	Facies association B	coal, parting (calcareous claystone and silty claystone)	band, seam splitting, bioturbation, lignite flake, rootlet	sheet-like	fresh-water gastropods, fish and amphibian fragments, plant remains	swamp/marsh	LACUSTRINE				
lithofacies B-1	Facies association B	calcareous claystone and silty claystone, carbonaceous claystone, with coal	lamination to medium bed bioturbation, load structure, lignite flake	sheet-like Sag-shaped	fresh-water gastropods, fish fragments, plant remains	fresh-water lake with swamp/marsh	LACUSTRINE				
lithofacies A-2	Facies association A	conglomeratic-sandstone, sandstone to claystone; thin coal bands	fining-upward sequences intraclasts, lamination, color mottling, lignite flake	sheet	plant debris rare fresh-water gastropods	Meandering river (channel & overbank	FLUVIAL				
lithofacies A-1	Facies association A	conglomerate, conglomeratic-sandstone to clayey siltstone	fining-upward sequences variegated color color mottling closed work fabric	(inadequate information)	rare fresh-water gastropod fragments	Braided river	FLUVIAL				

seam indicates that the lacustrine sedimentation had been interrupted by a relatively short period of silting up followed by the coal swamp environment. The preservation of leaves is significant. Flatened and complete whole leaves found in fine-grained clastics of this lithofacies (Photos A-4.10 and A-4.12 of Appendix 4) suggests quiet water deposition (Picard and High, 1972).

It is noted that the lacustrine sedimentation of lithofacies B-1 had been going on with penecontemporaneous gentle subsidence as evidenced from the extraordinary thick lacustrine sediments. Besides, the fine-grained central lake subfacies is mainly confined within the central part of the study area, whereas the marginal lake subfacies indicated by the influx of medium-grained clastics are found in the northern and southern parts of the study area.

Towards the end of the deposition of lithofacies B-1, the paleolake of Mae Moh had been silting up and the environment had accordingly changed from lacustrine to swamp or marsh environment. The sedimentation under the gentle and intermittent subsiding peat bog had continued. The sediments in this environment are indicated by at least 4 major cycles of relatively thick coal seam with partings of totally 30 metres thick. It is noted that the thickest coal seams with small amount partings are present in the eastern and southeastern part of the study area. This suggests that the optimum subsidence occurred in these two areas. If subsidence is too slow, the plant materials will be rotten and the peat will not be formed. If subsidence is too rapid, the swamps or marsh will drown and limnic sediments will be deposited. Therefore, seam splitting of lithofacies B-2 in the northern and southern area indicates the more rapid subsidence than the rate at which peat could be accumulated. It also indicates the influx of clastic sediments. However, the coal seam in northern area is higher splitting than in the southern area, indicating the maximum subsidence in the former one.

After the deposition of lithofacies B-2 the depositional environment of the Mae Moh basin had changed from swamp to freshwater lake of calcium-rich environment.

The lacustrine sediment of lithofacies B-3 is characterized by laminated to thin-bedded calcareous claystone with fish fragments and ostracod. The abrupt change of the lower contact between coal seam of lithofacies B-2 and lacustrine sediments of lithofacies B-3 suggests that the coal accumulation suddenly ended. In the upper part of the sequence, there is a thin coal band intercalated within lacustrine sediments indicating the short period of silting up to the paleolake. The maximum thickness of 38 metres of lake sediments and consistent lithology throughout the study area suggest that the sedimentation occurred contemporaneously with gentle subsidence perticularly in the lower part of the sequence. The presence of thin lignite band only in the northern and southern areas also indicates more slowly subsidence of those areas than in the central area. The abundance of slickenside or slip cleavage in this lithofacies probably resulted from the compactional subsidence of peat to coal of lithofacies B-2. The gradual increase of carbonaceous matter in the upper part of the lithofacies B-3 indicates the transitional changed of lacustrine of calcium-rich environment to more acid of swamp or marsh environment.

Towards the end of the deposition of lithofacies B-3, the swamp or marsh environment had peristed indicating by the formation of coal seam of lithofacies B-4. The siliceous hard band at the lower part of lithofacies B-4 indicates acid environment where siliceous solution was precipitated. The sediments in this environment are indicated by at least 4 major cycles of relatively thick coal seams with partings. These suggest that the coal swamp / marsh environment had been intermittent subsided during the time of deposition. It is noted that the thickest coal seam, up to 35 meters, with small amount of partings are present in the eastern and southeastern parts of the study area. This suggests the optimum rate of subsidence occurred in these two areas, whereas coal seam splitting in both northwardly and southwardly indicated more rapid subsidence in those two areas. The typical two partings (B4.4 Bed) of considerable thickness in the upper part of lithofacies B-4 indicate influx of clastic sediments into the coal swamp basin.

After the deposition of lithofacies B-4, the sedimentation in the Mae Moh basin had continued under a relatively rapid rate of subsidence. The depositional environment had changed from peat bog of lithofacies B-4 to calcium-rich fresh water-lake of lithofacies B-5

The lacustrine sediment of lithofacies B-5 is characterized by laminated to thin-bedded calcareous claystone with evidence of shallow water in the lower and upper parts of the sequence. Besides, evidence from the sharp contact between lithofacies B-4 and lithofacies

B-5 suggests that coal accumulation suddenly ended. The basinal subsidence is probably caused by reactivation of block-faulting coupled with compactional subsidence of underlying coal seams. The extraordinary thick lacustrine sediments indicates the sedmentation with penecontemporaneous subsidence of the paleolake. This lithofacies has a lateral consistency in lithology throughout the study area indicating the rather uniform of overall basinal subsidence. However, the presence of some beds of sandstone and conglomerate in the far southern area implies more rapid subsidence of the basin in some short periods. The abundance to common of gastropods, rootlet, lignite flake, bioturbation and intraformational conglomerate indicate silting up of the paleolake to swamp environment of lithofacies B-6. This is also supported by increasing upwardly of carbonaceous matters.

The lithofacies B-6 is characterized by alternation of weakly consolidated coal, calcareous fine-grained clastics, and some micrite bed with fresh-water fossils. The sedimentation of lithofacies B-6 had continued under the alternation of swamp environment and shallow fresh-water lake. However, the uppermost part of this lithofacies was influenced by overbank sediments. The depositional environment of this lithofacies was controlled by different rate of subsidence indicating by the presence of upto 13 thin to thick coal bands. This means that the optimum rate of subsidence, which peat could be accumulated, occurred for a short period. Where rapid subsidence occurred, sediments of lacustrine environment will be deposited. The rate of subsidence varies from place to place, the southern area had undergone rapid subsidence than the others resulting in the absence of coal and the presence of some beds of coarse-grained clastics. The subsidence of the area indicated in this lithofacies was caused by the load of the sediments, volume reduction from the transformation of peat to lignite and the syndepositional faulting within the basin. Some parts of the area were exposed and eventually eroded as shown by the presence of intraformational conglomerate. Strong bioturbation suggests the intensive organic activity in this lithofacies. The presence of fresh-water micrite beds and calcareous cement in fine-grained clastics indicate calcium-rich water, the calcium carbonate will be precipitated when the solution is allowed to lose its carbon dioxide to the surrounding air, or increase in concentration due to evaporation of the paleolake water.

5.3.3 Depositional environment of facies association C

During and after the deposition of facies association B, the central part of the present-day Mae Moh basin had been subsided under the influence of block-faulting oriented in the NNE / SSW zone. The sedimentation of facies association C had mainly continued within the graben structure under the fluvial environment. In the horst area, only thin sheet of fine-grained clastics were accumulated partly conformably and partly unconformably on the older rocks.

Lithofacies C-1 is characterized by red color fine-grained clastics with interbedding of gray color fine-grained clastics with rootlet in the lower part. The thickness of this lithofacies is ranging from 4 metres in the horst area to 277 metres in the graben area, and the overall geometry is shoestring shaped. The red coloration of fine-grained clastics of this lithofacies is believed to be the original red color of iron oxides in the oxidizing condition. However, some of the present-day red coloration are belong to post-deposition. This lithofacies suggests the low energy condition of overbank deposits of the fluvial environment in the subsiding flood plain (Reading, 1978) caused by penecontemporaneous block-faulting. The presence of gypsum crystal without banded structure is believed to be of secondary origin caused by the reaction between pyrite and calcareous materials.

Overlying conformably the lithofacies C-1 is the lithofacies C-2 characterized by a series of fining-upward sequence of weakly consolidated conglomerate to claystone with plant remains. The maximum thickness of this lithofacies is about 93 metres with overall prismatic shaped geometry. This sequence clearly represents the fluvial sedimentation of meandering river of relatively higher energy level. The high energy fluvial regime is believed to be the consequence of high topographic relief of the drainage area caused by displacement of faulting. It is also noted that a series of fluvial cycle of this lithofacies were resulted from the fluvial sedimentation in the subsiding river valley caused by continuous intrabasinal-faulting.

After the deposition of lithofacies C-2, the depositional environment of the Mae Moh basin had slightly changed from high energy fluvial regime to low energy fluvial regime. The sedimentation of this lithofacies had been continued only in the central zone of the study area under the influence of the block-faulting oriented in the NNE / SSW zone. The geometry of this lithofacies is prismatic shaped. This lithofacies is characterized by alternation of dominant red color silty claystone and claystone with siltstone and sandstone beds in the lower part while in the upper part of the sequence is represented by gray claystone, silty claystone and carbonaceous claystone with some impure coal. The alternation of red and gray of weakly consolidated claystone or silty claystone within the sequence indicate that the depositional environment had changed under the fluvial environment from sub-areal exposure of oxidizing environment to reducing environment. This lithofacies indicates the sedimentation of overbank deposits under the subsiding flood-plain caused by penecontemporaneous intrabasinal block-faulting.

Toward the end of lithofacies C-3, almost the Mae Moh basinal area had exposed and reoded. Later on, the coarse - to fine grained clastics of Quaternary under the fluvial environment have been deposited.

The salient characteristics and interpretation of these lithofacies with respect to the tectonic influence is summarized in Table 5.3. 1a. The schematic model of the Mae Moh basin development and depositional history is shown in Figure 5.3.3a.

5.4 Tectonic sedimentation

From the analyses of sub-surface geological data of Mae Moh basin in terms of lithostratigraphy, lithofacies, and environmental of deposition, it is apparent that factors controlling deposition may be considered to have of operated on two scales. The first one is a larger one on basinal scale, and the second one is smaller one on intrabasinal scale. On a basinal scale, sedimentation seems to have been controlled by a combination of structurally and compactionally induced subsidence, and depositional environment. On a

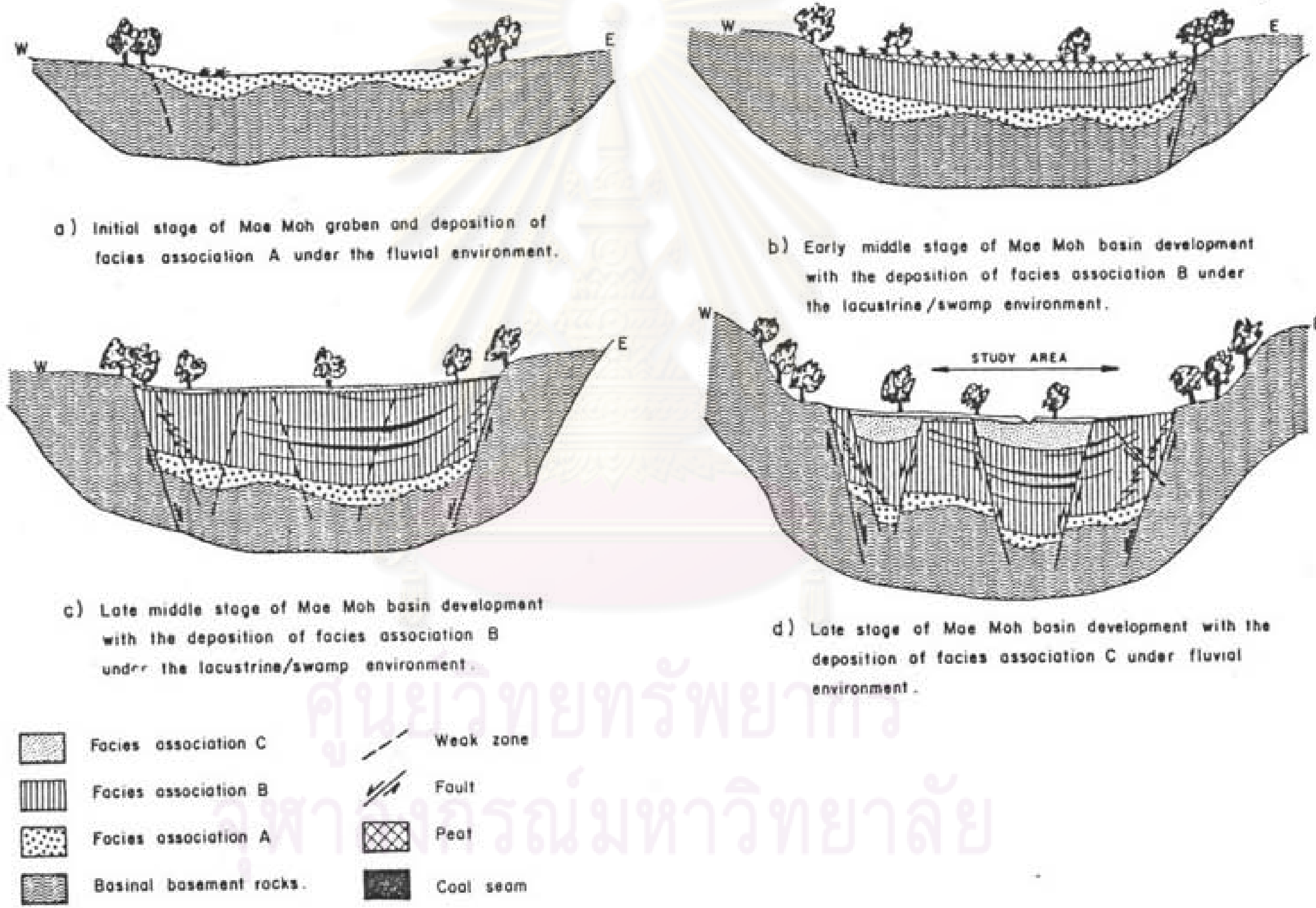


Fig. 5.3.3 a Schematic model of the Mae Moh basin development and depositional history.

intrabasinal scale, the post-depositional gravity faulting seems to have been controlled by a combination of compaction and extensional tectonic regime.

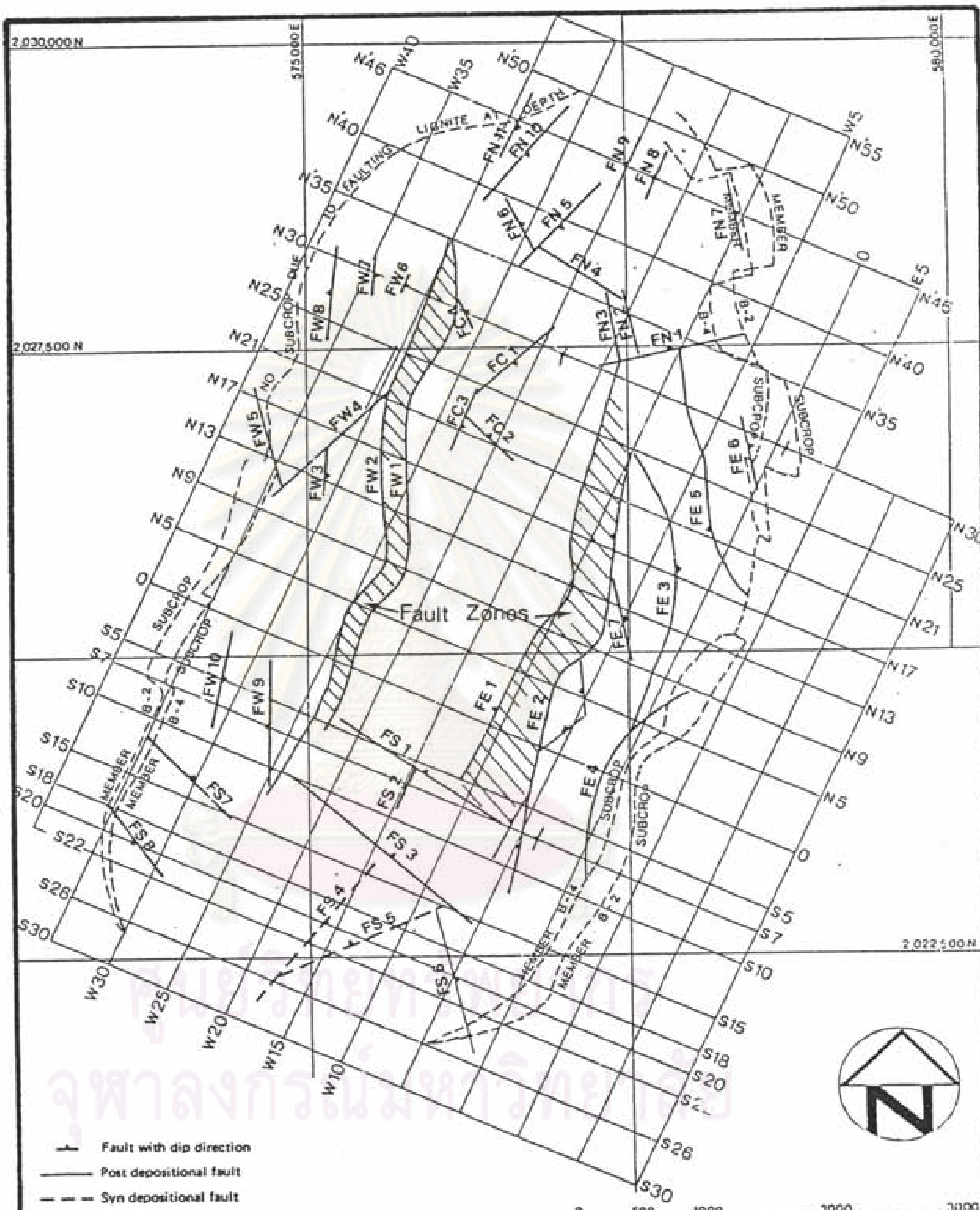
The evolution of the Mae Moh depositional basin was initiated by the remnants of subtle graben style topographic low created by activation or reactivation of structural weaknesses. These two major fault lines marking the boundaries of the graben are located outside the study area. These basinal faults controlled the rate of subsidence, rate of deposition, and depositional environment of the Mae Moh basin. Besides, the basinal subsidence has strong influenced on thickness of sediments infilled which can be used as hypocenter of the deposition. According to the syndepositional basin model, the thickness of the sediments is thickening toward the central area of the graben. On the basis of lithofacies thickness, the hypocenter of the lower sequence of lithofacies B-1 is located in the central area of the present-day Mae Moh basin, while the hypocenter of the upper sequence of lithofacies B-1, lithofacies B-2, B-3, and B-4 were located in the eastern or southeastern parts of the study area. The shift of the hypocenter is probably caused by differential displacement of the fault on both sides of the graben. The subsidence caused by tectonic movement ie. structural faulting, block faulting is believed to have direct influence on the change of one-type depositional environment to the other such as from fluvial environment to lacustrine environment. With regard to rate of subsidence, the subsidence due to structural faulting appears to have a relatively rapid rate as compare with subsidence due to compaction.

The intrabasinal scale faults are analyzed in terms of syndepositional and post-depositional faults with respect to various lithostratigraphics concerned. Besides, their are a number of intrabasinal faults which can not be identified on the basis previously set up and are therefore classified under undifferentiated fault (Figure 5.4a and Table 5.4a).

The intrabasinal fault has a direct effect on the displacement of lithofacies deposited before the faulting. The middle part of the study area is a graben about 1.5 kilometres wide, trending in NNE/SSW direction and bounded on eastern side by fault no. FE1 and FE2, and western side by fault no. FW1 and FW2 (see Figure 5.4a) of major intrabasinal fault zones,each of which has a total throw of more than 200 metres along much of its length. Besides, the intrabasinal fault has a direct effect on local subsidence which indirectly controlled the nature of depositional environment, thickness of lithofacies, lithological characteristics, and hypocenter of deposition. The hypocenter of facies association C is located in the central part of the present Mae Moh basin is also located in the central area. It is also believed that the present-day topography of Tertiary basin is partially controlled by this intrabsinal fault.

It is also noted that the load of thick sedimentary sequence within Tertiary basin has influence on compaction of underlying sediments and the trigger mechanism for both basinal and intrabasinal faulting.

In conclusion, the nature and characteristics of Tertiary sediments in the basin, namely, depositional environment, lithology,



- Fault with dip direction
- Post depositional fault
- Syn depositional fault
- Undifferentiated fault
- Subcrop boundary of Members B-2 and B-4

Sedimentological Studies of Some Tertiary Deposits of Mae Moh Basin, Changwat Lampang	Informal name of faults on floor of B-2 Member
Pol Chaodumrong, Department of Geology Graduate School, Chulalongkorn University, 1985.	Fig. 5.4a

Table 5.4a Classification of the faults in the study area. Fault names are referred to Figure 5.4a. Note solid line, post depositional fault; dash, syndepositional fault; blank, no information; dotted; undifferentiated fault.

Fault Name	Lithostratigraphic unit							
	C-3	C-2	C-1	B-6	B-5	B-4	B-3	B-2
FE 1	dash	dash	dash	solid	solid	solid	solid	solid
FE 2	dash	dash	dash	solid	solid	solid	solid	solid
FE 3			dotted	solid	solid	solid	solid	solid
FE 4					solid	solid	solid	solid
FE 5				solid	solid	solid	solid	solid
FE 6					solid	solid	solid	solid
FE 7			dotted	dotted	solid	dotted	dotted	dotted
FN 1			dash	solid	solid	solid	solid	solid
FN 2			dash	solid	solid	solid	solid	solid
FN 3			dash	dash	dash	solid	solid	solid
FN 4				solid	solid	solid	solid	solid
FN 5			dash	dash	solid	solid	solid	solid
FN 6				solid	solid	solid	solid	solid
FN 7						solid	solid	solid
FN 8				dash	dash	solid	solid	solid
FN 9				dash	dash	solid	solid	solid
FN 10				dash	dash	solid	solid	solid
FN 11					solid	solid	solid	solid
FW 1	dash	dash	dash	dash	solid	solid	solid	solid
FW 2	dash	dash	dash	dash	solid	solid	solid	solid
FW 3			dash		solid	solid	solid	solid
FW 4			dash		solid	solid	solid	solid
FW 5					solid	solid	solid	solid
FW 6					solid	solid	solid	solid
FW 7					solid	solid	solid	solid
FW 8				dash	solid	solid	solid	solid
FW 9				dash	solid	solid	solid	solid
FW 10		dash	dash	dash	solid	solid	solid	solid
FS 1			dash	dash	solid	solid	solid	solid
FS 2			dash	dash	solid	solid	solid	solid
FS 3		dash	dash	dotted	solid	solid	solid	solid
FS 4	dash	dotted	dotted	dash	dash	dash	dash	dash
FS 5				dash	dash	dash	dash	dash
FS 6		dotted	dotted	dotted	dotted	dotted	dotted	dotted
FS 7	dash	dash	dash	dash	dash	solid	solid	solid
FS 8	dash	dash	dash	dash	dash	solid	solid	solid
FC 1			dash	solid	solid	solid	solid	solid
FC 2			dash	solid	solid	solid	solid	solid
FC 3			dash	solid	solid	solid	solid	solid
FC 4			dash	solid	solid	solid	solid	solid

thickness, and lateral continuity of sedimentary unit are controlled by subsidence which may be caused by faulting or compaction or the combination of both. The tectonic regime and the load of sediments infilled are, however, believed to be the major factor that controlled faulting and compaction.