CHAPTER VI

CONCLUSION

Mae Moh basin in one of the Tertiary intermontane basin located in Changwat Lampang, northern Thailand. The importance of Mae Moh basin is basically owning to the large coal deposit which has been currently exploited for power generation by the Electricity Generating Authority of Thailand, The area has been chosen for detailed study on the basis of adequate subsurface geological and geophysical data and information for sedimentological analyses. Besides, the finding of the present study might be useful in assisting the current coal development programmes of the EGAT. It is also anticipated that the geological records of the basin will be destroyed by the current open-pit mining operation, and the study regarding this aspect will be a non-replaceable contribution for future reference.

The study area is mainly confined within the main sub-basin of the Mae Moh basin covering in area of approximately 32 square kilometres with altogether 178 boreholes of average depth range of 150 to 300 meters. Among these, there are existing 165 boreholes with geological and geophysical logs. Besides, there is a 33 line-kilometres of seismic reflection survey data available. Attempt has been made under the present investigation to prepare the geological map of the basin and neighbouring area, to conduct geological borehole logging of 10 primary reference wells including the core sampling programme for further detailed study. Several direct observations on the geological conditions of the active mine pit have also been made during

geological field survey in order to obtain the better picture of subsurface geological condition. Consequently, standard drill-chart of 10 primary reference wells, 5 geological sections, 14 isopach maps, 8 structural contour maps and several lithostratigraphic columns have been prepared to serve as the baseline information for lithostratigraphic analysis of Tertiary sedimentary sequence of Mae Moh basin. Besides, the depositional environment of the Mae Moh coal deposit has been proposed in this study as well as the semi-quantitative analysis of relative degree of abundance of clay minerals of the B-Formation using X-ray diffractometry techqiue. The lithostratigraphic analysis is a prerequisite of the sedimentary basin analysis, because there is an obvious relationship between the characteristics of a given sedimentary environment and the sediment that accumulate there. Therefore, the lithofacies and facies association have been established because their recognitions provide the basis for on environmental interpretation of lithostratigraphic units. On this basis, names of the lithofacies and facies association are corresponding to the informal names of the members and the formations proposed respectively. According to these basis, the reconstruction of the depositional environment or the so-called basin analysis of the Mae Moh basin is clearly shown from this study.

The Mae Moh Group lies unconformably on the highly folded pre-Tertiary rock, such as, the rocks of Hong Hoi and Doi Chang Formations. It also underlies unconformably the coarse - grained terrigenous sediments of Quaternary Period. The lithostratigraphic relationships of the smaller units of Mae Moh Group are conformable to each other except the C - Formation which lies partly conformably

and partly unconformably on the B-Formation.

The proposed lithostratigraphy of Tertiary succession of the Mae Moh basin is characterized as Mae Moh Group which has been further subdivided into 3 formations, 11 members, and 9 beds in ascending order as : A-Formation (A-1 and A-2 Members), B-Formation (B-1, B-2, B-3, B-4, B-5, and B-6 Members), and C-Formation (C-1, C-2, and C-3 Members). Furthermore, the B-2 Member has been subdivided into 4 beds in ascending order as B2.1, B2.2, B2.3, and B2.4 Beds; the B-4 Member has also been subdivided into 5 beds in ascending order as B4.1, B4.2, B4.3, B4.4, and B4.5 Beds. All lithostratigraphic units recieve their informal name at this stage.

The A-, and C-Formation are characterized by fine-to coarse-grained clastic associations while the B-Formation is made up predominantly of fine-grained clastics and coal seams. The sequence of A-, B-, and C-Formations is called facies association A, B, and C, respectively. The board picture of depositional environment of facies association A, B, and C are fluvial, lacustrine, and fluvial, respectively.

The lower part of A-Formation, A-1 Member, of 9-52 metres thick is made up of a series of fining-upward sequence of weakly consolidated conglomerate,conglomeratic sandstone to clayey siltstone. The upper part of A-Formation, A-2 Member, of upto 88 metres thick consists of a series of fining-upward sequence of variegated color of weakly consolidated conglomeratic sandstone or sandstone to claystone with minor coal seam in the upper part of the sequence. These member, A-1 and A-2 Members, distinguish by the ratio between

coarse-grain and fine-grain clastics. The latter has the equal proportion of sands and clays, while the former one consists mainly of coarse-grained clastics.

The sequence of the A-1 Member is called lithofacies A-1. The depositional environment of this lithofacies is concluded to be of braided river deposited in the high relief alluvial plain resulted from block-faulting. The sequence of the A-2 Member is called lithofacies A-2 and its depositional environment is concluded to be of meandering river type.

The lowermost sequence of the B-Formation, B-1 Member, of about 38-217 metres thick is characterized by thin-to medium-bedded calcareous claystone and silty claystone with carbonaceous claystone in the lower part; laminated to thin-bedded calcareous claystone and silty claystone as well as carbonaceous claystone in the upper part of the sequence. At the upper one-third of the sequence the sediment is represented by the widely distributed thin coal seam. It is noted that the presence of gastropods, bioturbation and lignite flakes are closely related to the coal band.

The sequence of the B-1 Member is called lithofacies B-1. The depositional environment of this lithofacies is concluded to be of fresh-water lake (lacustrine) with the calcium-rich environment under the influence of the penecontemporaneous subsidence caused by block-faulting and compaction of the underlying sediments. However, deposition was interrupted by a short period of swamp/marsh environment at the upper one-third of the sequence.

The B-2 Member is the lower major coal seam. It is subdivided into 4 beds, each bed of which is characterized by coal in the upper part and major parting in the lower part except the B2.1 Bed which is made up mainly of coal.

The sequence of coal seam of the B-2 Member is called lithofacies B-2. This sequence suggests that it was deposited in swamp/marsh environments under the gentle and intermittent subsidence.

The B-3 Member, about 15-38 metres thick, consists mainly of laminated to thin-bedded calcareous claystone, calcareous silty claystone and carbonaceous claystone with locally occurred thin coal band. The bioturbation, intraformational conglomerate, fish fragments, gastropods, ostracods and lignite flakes are common to abundant in place.

The sequence of the B-3 Member is called lithofacies B-3. This sequence suggests that it was deposited in fresh-water lake (lacustrine) of calcium-rich environment under the influence of penecontemporaneously and gentle subsidence. The subsidence of the basin was probably caused by reactivation of block-faulting, load induced compaction of the underlying sediments as well as the volume reduction of peat in the diagenetic processes of coalification.

The B-4 Member, about 20-80 metres thick, is another major coal seam which has been currently exploited. It is subdivided into 5 beds, the B4.1 and B4.5 Beds are characterized by coal, the B4.2 and B4.3 Beds are characterized by coal in the upper part and major parting in the lower part, and the B4.4 Bed which is one of the

marker beds that make up predominantly of parting with some coal intervention. The lower part of this member is represented by thin bedded siliceous hard band. This hard band is very dense and compacted. This member contains fossils of gastropods, fish fragments. amphibian fragments, turtle and mastodon in place. The sequence of coal seam of B-4 Member is called lithofacies B-4. This lithofacies suggests that it was deposited in the swamp/marsh environment of intermittent subsiding-basin. The thick bands of coal with few partings indicate the optimum rate of subsidence in the central area whereas thin coal bands with thick partings in the northern and southern areas indicate that subsidence rate was greater than the rate of peat accumulation. The siliceous hard band within the B4.1 Member is concluded to be both chemical preciptation nature and detrital origin.

The B-5 Member, about 60-100 metres thick, is characterized by laminated to thin-bedded calcareous claystone, silty claystone and carbonaceous claystone. Gastropods, fish fragments, ostracod, lignite flakes and rootlet are common throughout the sequence, while the bioturbation, load structure and intraformational conglomerate common in the upper and lower parts of the sequence. It is noted that some beds of sandstone and conglomerate are present in the southern part of the area. The sequence of the B-5 Member is called lithofacies B-5. The depositional environment had suddenly changed from swamp/marsh environment of lithofacies B-4 to fresh water Lake of calcium-rich environment of lithofacies B-5 under the influence of gentle subsidence caused by reactivation of the basinal block-faulting, load-induced compaction of the underlying sediments and volume reduction of peat in coalification processes. The B-6 Member, about 15-65 meters thick,

is characterized by the alternation of weakly consolidated of thin to thick band lignite, impure coal,calcareous claystone and silty claystone, with some bed of micrite. Melanoides sp., Viviparus sp., ostracod, fish fragments, plant debris are common to abundant. Various types of sedimentary structures, namely, bioturbation, intraformational conglomerate, load structure and pull-apart structure are also common. It is noted that in the southern area, the sequence contains some beds of sandstone and conglomerate while coal appears as trace. The sequence of the B-6 Member is called lithofacies B-6. This sequence suggests that it was deposited in alternation of freshwater shallow lake and swamp environment. However, the uppermost part of the sequence is represented by the overbank sediments.

The C-Formation comprises of 3 member. The lowermost member, C-1 Member of 4-277 metres thick is mainly characterized by semiconsolidated red color silty claystone and claystone with color mottling, calcrete, gypsum crystal, rootlet and gray calcareous claystone fragments. However, the lower part of the sequence is represented by interbedding of gray and red color claystone/silty claystone. The sequence of the C-1 Member is called lithofacies C-1, this lithofacies suggests that it was deposited in low energy condition of overbank deposits of the fluvial environment in the subsiding flood plain. The red coloration of the fine-grained clastics is believed to be both primary and secondary red color. The gypsum in C-1 Member is of secondary origin.

The C-2 Member, about 2-93 metres thick, is characterized by a series of fining-upward sequence of weakly consolidated conglomerate

or sandstone to claystone with color mottling, calcrete, plant remains, gypsum crystal and calcrete. The sequence of the C-2 Member is called lithofacies C-2. This lithofacies indicates that it was deposited in the meandering river type of fluvial environment.

The C-3 Member of upto 190 metres thick is mainly characterized by weakly consolidated red color of claystone, silty claystone with some beds of siltstone and sandstone, color mottling, calcrete, and gray claystone fragments. The upperpart of this member is represented locally by weakly consolidated gray claystone, carbonaceous claystone and impure coal. The sequence of the C-3 Member is called lithofacies C-3. This lithofacies indicates the sedimentation of overbank deposits under the subsiding flood plain caused by penecontemporaneous intrabasinal block-faulting.

The attitude of all the sequences are sub-horizontal except those located close to faults. The marker beds for lithostratigraphic correlation in this area are all coal seams and bands, siliceous hard band within B4.1 Bed, typical two parting of B4.4 Bed and gastropod beds within the B-1 Member. Besides, the lithology of each lithostratigraphic unit is rather unique which produces specific signature of geophysical logs.

The factors which controlled the deposition have been considered on two scales. The larger one is the basinal scale, and the smaller one is the intrabasinal scale. 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. The basinal fault of basinal scale, is located

out side the study area. These basinal faults controlled the rate of subsidence, rate of deposition and depositional environment of the Mae Moh basin. The intrabasinal faults of intrabasinal scale, are analyzed in terms of syndepositional fault,postdepositional fault with respect to various lithostratigraphic units concerned and undifferentiated fault. Almost of intrabasinal faults was created during the deposition of B-6 Member and C-Formation. Therefore, the intrabasinal fault has a direct effect on the displacement of all lithofacies underlying the lithofacies B-6. Besides, it also had a direct effect on the local subsidence which indirectly controlled the nature of depositional environment, thickness of lithofacies, lithological characteristics on numerous lithofacies overlying the lithofacies B-6. It is noted that the differential displacement of faults on both sides of the graben caused the migration of the depositional hypocenter of basin. 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 hypocenters of the upper sequence of lithofacies B-1, lithofacies B-2, B-3, and B-4 are located in the eastern or southeastern parts of the study area. The present-day deepest zone and hypocenter of facies association C are located in the central of the study area. The shift of the hypocenter of the latter one was caused by intrabasinal fault zones. It is also believed that the present-day topography of the Mae Moh basin is partially controlled by this intrabasinal fault. The present-day configuration of the study area of Mae Moh basin is shown by graben structure in the central area, whereas the horst area of eastern side shows relatively higher degree of uplifting as compared with that of the western one.

The coal measures of the Mae Moh basin is characterized as B-Formation. It contains 2 major coal seam (referred to as B-2 and B-4 Member) which have been economically exploited, 2 minor coal seams (referred to as part of the B-1 Member, and the B-6 Member), and one coal band within the B-3 Member. Besides, some parts of A-2 and C-3 Members are represented by coal bands.

The coal rank of the major coal seams have been determined on the moist, mineral matter-free basis using the Parr Formulas. The modal value of calorific values of these major seams indicate the range of lignite-A of ASTM classification. However, some of them show the range of subbituminous coal. For general name, coal of Mae Moh basin is concluded to be lignite, Lignite of the B-2 Member shows a relatively higher calorific value and high sulfur content than those of B-4 Member.

The lignite of the Mae Moh basin is a humic coal or banded type. It is mainly autochthonous coal and originated largely from herbaceous and semi-aquatic plant materials under the influence of calcium-rich water swamp or marsh environment. The compaction ratio of peat to lignite of the Mae Moh basin is about one-third or one-fourth.

With regard to the two major coal seams, it is apparent that the good quality of both coal seams with few partings are thickening in eastern or southeastern and thinning westwardly. The coal seams are rapidily splitting with increase in thickness of both coal seam and parting towards the northern and southern parts of the study area. In these two latter areas, the coal is of poor quality. The degree

of seam splitting of the lower major coal seam, B-2 Member, in northern area is higher than that in the southern area while the upper major coal seam, B-4 Member, is splitting in the southern area more than that in the northern area. The seam splitting in those areas indicates the higher rate of subsidence than the rate at which peat could be accumulated.

With respect to the detailed laboratory study of clay mineral of the B-Formation and pre-Tertiary rocks. Altogether 43 samples have been semi-quantitative analyzed using the X-ray diffractometry technique. The findings of the study are as follows : the clay mineral groups of fine-grained clastics are illite, kaolinite and montmorillonite ; illite is the major constituent ; kaolinite content shows antipathetic relationships with montmorillonite; kaolinite has a tendency to increase toward coal band especially in the parting; illite, kaolinite are found in all samples but montmorillonite is mainly confined within B-5 Member.

Despite the fact that there are at least sixty Tertiary Basins in Thailand, very little is known about Tertiary sediments in these basins, geologically, stratigraphically, and sedimentologically. The difficulty confronting the analysis of Tertiary succession is that almost all of them are covered with Quaternary deposits or partly exposed. However, a few basins have been explored by geophysical surveys and drilling methods. Mae Moh basin is among few Tertiary basins which have been intensively explored for coal development programme. Therefore, attention had been paid on the available subsurface data and information for geological, stratigraphical and sedimentological analyses.

It is anticipated that the full understanding of Tertiary sedimentation of Mae Moh basin will be a steping stone to the understanding of other intermontane basins particularly in northern Thailand. Besides, this study will undoubtedly throw some lights on the Tertiary stratigraphy of Thailand.

Apart from the contribution on the "pure" geological aspects of the present investigation, it is envisaged that the depositional model of Mae Moh basin could also serve as a key for exploration and production models for various type of geological resources, namely, coal, petroleum, oil shale, industrial clays, diatomite, ete.