CHAPTER II

GEOLOGY

In order to fully understand the origin of the basin formation of the Mae Moh Tertiary basin, it is considered that the geological setting of the study area and neighboring area, stratigraphy as well as the tectonic and sedimentation of the basin including the structural features of the area should be well established. Therefore, the discussion in this chapter is focussing upon the geological setting and geological evolution of the area.

2.1 Geological setting of the study area and neighboring area

The geological setting in the neighboring area of Mae Moh basin were previously reported by various authors, namely, Pitakpaivan (1955), Piyasin (1971, 1972, 1975), Liengsakul (1979), Chonglakmani (1981, 1984), etc. An attempt has been made here to remap the area with emphasis on the areal extent of Tertiary deposits (Figure 2.1 a). It is noted that the lithostratigraphic boundaries of rocks are slightly modified. However, the units name used in this study remain unchange according to Chonglakmani (1981).

The Lampang Group is first proposed by Piyasin (1971) which was further subdivided on the bases of age and lithology into 5 formations. Later on, Liengsakul (1979) supervised by Piyasin had reconsidered the Lampang Group and included only 4 formations of marine sediments in this Group, namely, Phra That, Pha kan, Hong Hoi and Doi Chang Formations in ascending order. As a consequence, the Pha Daeng Formation is now excluded from the Lampang Group because of

GEOLOGICAL MAP
of
MAE MOH BASIN

MAE MOH BASIN

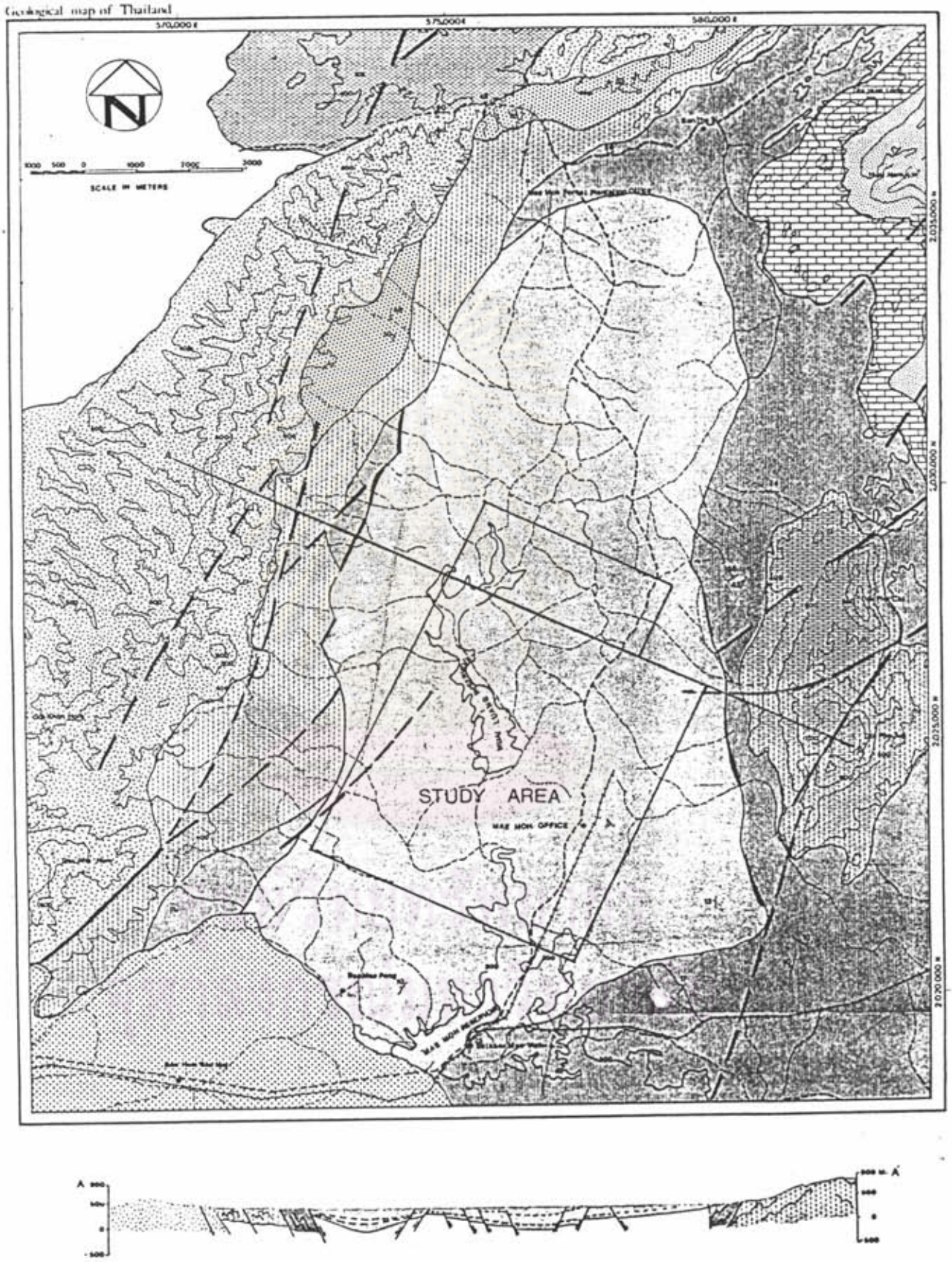


Fig. 2.1a Geological Map of the Mae Moh Basin.

its continental origin and believed to be equivalent to the Nam Pha Formation of the continental Khorat Group (Chonglakmani, 1972). Recently, Chonglakmani (1981, 1983) has revised the classification of Lampang Group in ascending order as, Phra That, Doi Chang, Hong Hoi and Doi Long Formations. The comparative classification from previous works of Lampang Group is shown in Table 2.1a and the classification of Chonglakmani (1981) is employed in this study.

At present, the shape of the Mae Moh basin is roughly triangular elongated in the NNE/SSW direction following the regional strike of the older formations. The western and northern parts of the basin are bounded by Permo - Triassic volcanic rocks of Volcanic Formation and by Marine Triassic of Lampang Group which are oriented in the approximate northeast - southwest direction. Further north, the area is occupied by Huai Thak Formation of the Ratburi Group. The eastern and northeastern parts of the basin are bounded by low terrain of Hong Hoi Formation with rocks of Doi Chang Formation exposed as high-relief mountains farther away. One obvious synclinal structure of Doi Long and Pha Daeng Formation are oriented approximately in the northeast-southwest direction. The southern part of the basin is covered by basalt trap of Pleistocene age (Figure 2.1 a).

Huai Thak Formation is proposed by Piyasin (1972) as a upper formation of Ratburi Group and exposed in the northern part of the mapped area (Figure 2.1a). The lithology of this formation is characterized by dark gray shale with intercalation of reddish brown sandstone, conglomerate, light brown limestone with some rhyolite and andesite fragments occuring in sandstone and conglomerate. Fossils of

Table 2.1a Development of the Stratigraphic Classification and Nomenclature of the Lampang Group in Vicinity of Mae Moh Basin by Various Authors (modified after Chonglakmani, 1981).

Pitakpaivan (1955)	Piyasin (1971)		Piyasin (1972)		Chonglakmani (1972)		Liengsakul (1979)		Chonglakmani (1981)		Present Study	
	Lampang Group	Pha Daeng	Lampang Group	Pha Daeng	Lampang Group	Pha Daeng	Lampang Group	Pha Daeng	Lampang Group	Pha Daeng	Lampang Group	Pha Daeng
		Doi Long		Doi Chang		Doi Chang		Doi Chang		Doi Long		Doi Long
Hong Hoi		Hong Hoi		Hong Hoi		Hong Hoi		Hong Hoi		Hong Hoi		Hong Hoi
Doi Chang LST. Doi Chang SH & SS LST Cgl. Foss. LST Calc. SS & oolite Pha Kap LST		Pha Kan		Pha Kan		Pha Kan		Pha Kan		Doi Chang		Doi Chang
		Phra That		Phra That		Phra That		Phra That		Phra That		Phra That

brachiopods, pelecypods and bryozoa indicate that the age of the formation is ranging from Kazanian to Kungurian of Upper Permian (Piyasin, 1972).

Volcanic Formation flanks the western and northern parts of the study area as a high mountain range elongated in the northeast-southwest direction. Normally, the formation overlies conformably on the Huai Thak Formation and underlies disconformably the marine Triassic Lampang Group. The lithology is characterized by rhyolite, tuff, agglomerate and andesite which are exposed at Doi Chao Nai, Doi Farang and Doi Pha Hom areas.

Phra That Formation is exposed as small area in the western part of the mapped area consisting of sandstone, siltstone and conglomerate with occasionally intercalated bedded limestone. These rocks are generally coarse grained and red in coloration at the base, and gradually decreasing in grain size upward with green to gray color. They are believed to have been deposited in near-shore and partly continental environments. One locality of fossil has been found and later identified by Dr. Chongphan Chonglakmani as Pteria sp. The age of this formation from previous works ranges from Lower Triassic to Middle Karnian (Chonglakmani, 1981).

Doi Chang Formation lies conformably on Phra That Formation and underlies conformably the Hong Hoi Formation. In the eastern part of the mapped area (Figure 2.1a) the formation consists predominantly of bedded and massive gray to dark gray limestone, while in the western part the formation consists of bedded gray limestone, gray to green shale and sandstone (Figure 2.1a). The interbedding of gray to dark

gray limestone, gray to green shale and sandstone in the west probably reflect the facies change of near - shore environment. Chonglakmani (1981) reported that age of this formation range from Upper Anisian to Upper Karnian.

Hong Hoi Formation normally underlies the areas of rolling topography which are widespread in the eastern part, and some areas of limited areal extent in the western part of the mapped area. This formation forms the basement of Tertiary strata which is evident from borehole LM 2813 S. The lithology is characterized by predominant gray to greenish gray shale with ellipsoidal fracture, and sandstone, siltstone, conglomerate as well as some interbedded argillaceous limestone. Numerous marine bivalves and ammonoids were found in this formation which indicated ages ranging from Scythian to Lower Norian.

Doi Long Formation in the present study is a synonym of Doi Chang Formation of Piyasin (1972). It is considered to be the topmost formation of Lampang Group which lies conformably on Hong Hoi Formation and is disconformably overlain by Pha Daeng Formation. Doi Long Formation is exposed around the flanks of the Doi Pha Daeng Syncline in the northeastern part of the mapped area. The lithology is characterized by gray to light gray finely crystalline limestone. It is predominantly massive, but gradually well bedded near the base and the top of the formation. The age of the formation is considered to be Middle Karnian on stratigraphic position (Chonglakmani, 1981).

The stratigraphic sections of Lampang Group in the vicinity of Mae Moh basin is shown in Figure 2.1 b.

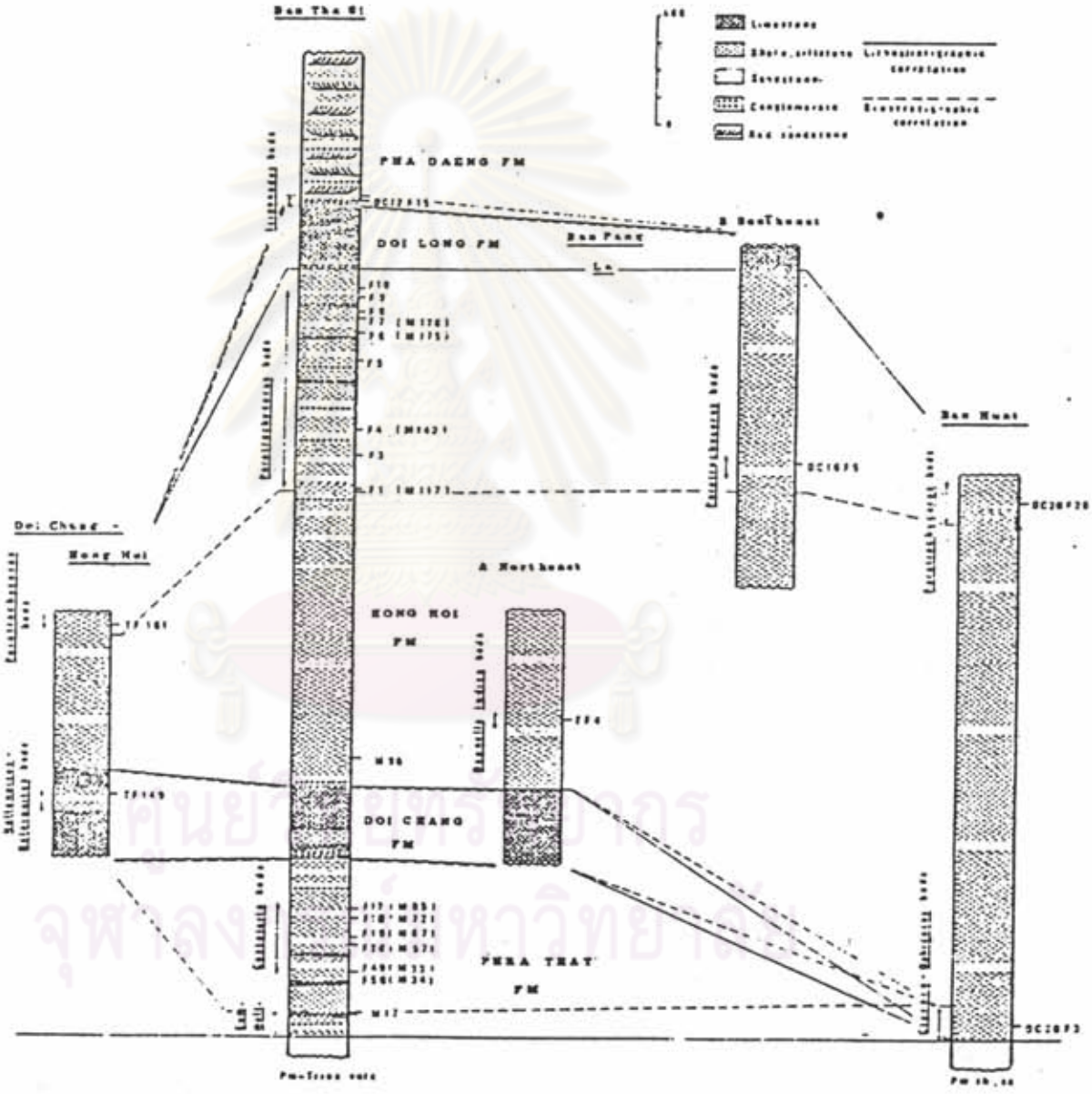


Fig. 2.1b Stratigraphic Sections of the Lampang Group in Mae Moh Belt (after Chonglakmani, 1981).

Pha Daeng Formation forms synclinal structure in the northeastern part of the mapped area (Figure 2.1a). In the present study, it is recognized as an independent lithostratigraphic unit excluded from the Lampang Group on the account of its red-bed character and its disconformable contact. The lithology is characterized by a sequence of limestone conglomerate and argillaceous limestone at the base passing upward to red conglomerate, sandstone and shale at the top. From the macrofauna found near the base of the formation, the age is concluded to be Middle Karnian.

The youngest strata in the Mae Moh area are sequence of unconsolidated sediments which lie nearly horizontal upon the bevelled edges of folded older rocks. It is generally exposed as small hills in the southern part of the study area at Ban Mae Pong, and some areas of residential quarter in the Mae Moh lignite mine. Evidence from the borehole in the vicinity of line W23 indicates that the thickness of unconsolidated sequence is over 50 metres. The lithology is mainly characterized by gravel at the base passing to finer clastic associations at the top. Clasts are generally rounded with low to moderately sphericity of sandstone, conglomeratic sandstone and volcanic rocks.

In the southern part of the mapped area, it is covered by several phases of basalt flow forming elevated flat surface. This basalt is called "Mae Tha basalt" consisting of dark gray to black, fine - grained, vesicular and usually flows as pahoehoe type. Thin- section study by Jungyusuk and Sirinawin (1983) revealed that this basalt has a microporphyritic texture with abundant olivine microphenocrysts. Barr and Macdonald (1978), and Vichit et al.(1978) classified Mae Tha

basalt as basanite and basanitoid, respectively. The age of Mae Tha basalt, base on paleomagnetic ground, indicate the ranging of 0.69 - 0.95 my. (Barr et al., 1976). It is noted that there are two small cones in the north of Ban Pa Lad, namely, Pha Kok Hin Foo and Pha Kok Jum Pa Dad which are aligned in the north-south direction. These cones generally show the opening in the northern flank of the craters (Jungyusuk and Sirinawin, 1983).

2.2 Present status of Tertiary stratigraphy

Previous investigations on the intermontane Tertiary basin in the northern part of Thailand reveal that the Tertiary formation overlies unconformably on pre-Tertiary rocks and underlies unconformably the unconsolidated sediments of the Quaternary age. The lithology is described as sediments of lacustrine and fluviatile origins, and almost all of them are believed to contain coal deposits. Various macrofauna and flora were found and identified. However, these fossils were collected from a limited stratigraphic interval which has led to conflicting age assignations of the basins. Due to the fact that almost all of the Tertiary deposits are not exposed and almost all of drilled holes are carried out for economic purpose which penetrated only a few metres below the coal, oil shale or prospecting materials. Very limited boreholes reached the basement of pre-Tertiary rocks. Therefore, the knowledge on the whole Tertiary stratigraphy of those basins are very limited, even in the Mae Moh basin which have thousands of boreholes, the stratigraphy of the basin is partly established only in early 1984. The data which are obtained from the so-called " stratigraphic hole" have drastically altered the picture of previous stratigraphic works. It is interesting to note that the useful concepts of

sedimentary facies and depositional environment which are obviously proved to be the most valuable exploration criteria have been completely neglected in the past.

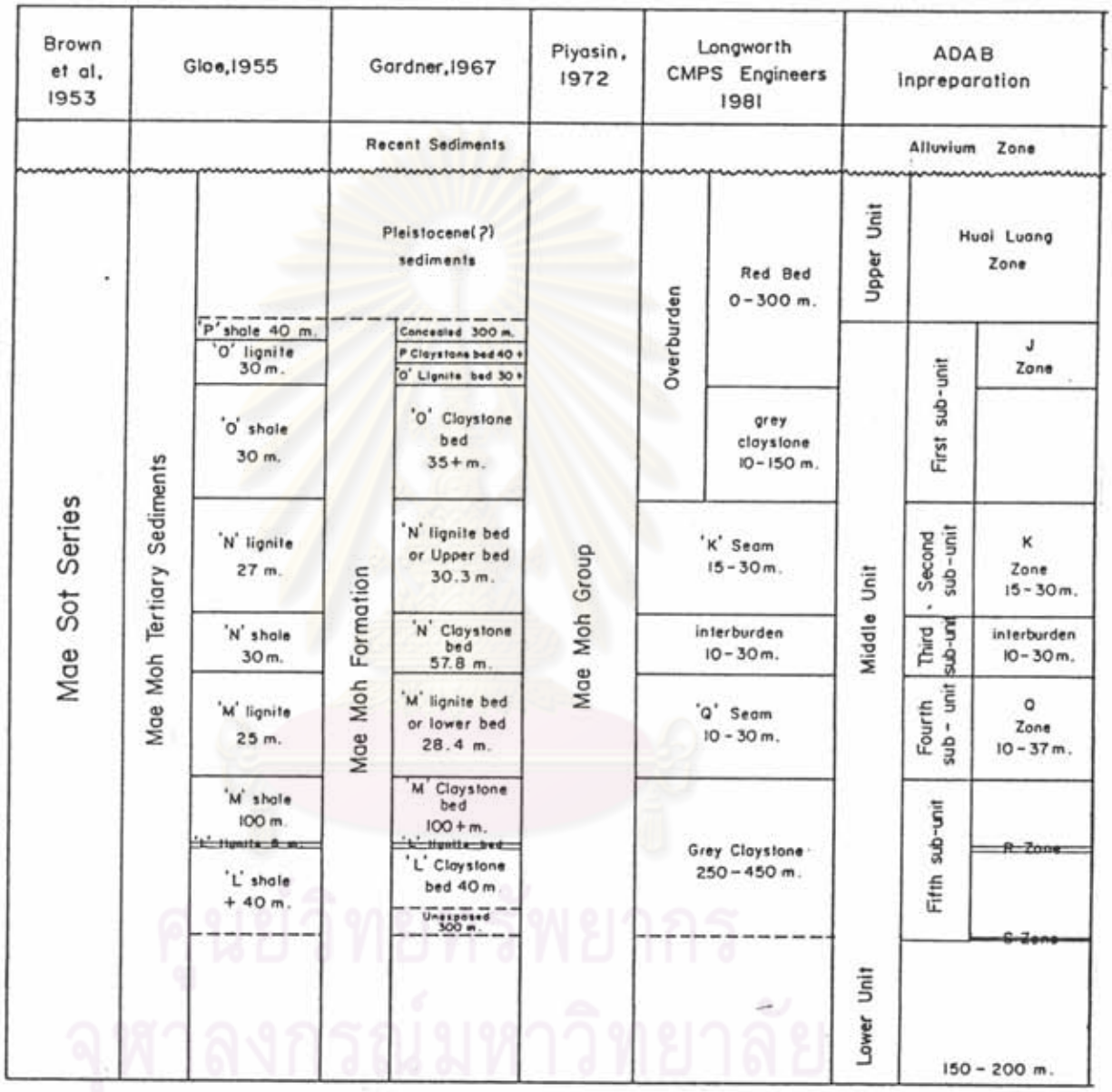
2.2.1 Previous classification

The term "Mae Sot Series" was first used in the report of Brown et al. (1953) to represent the Tertiary rocks of semiconsolidated fluviatile and lacustrine sediments in the northern part of Thailand. They also reported the lignite deposit in the Mae Moh basin as the Mae Moh lignite.

Gloe (1955) and Sithiprasasna (1959) used the term Mae Moh Tertiary Sediments to describe the Tertiary sequence which contained lignite in the Mae Moh basin. Four major lignite beds have been recognized and assigned in alphabetical sequence from bottom to top, namely, L Shale, L Lignite, M Shale, M Lignite, N Shale, N Lignite, O Shale, O Lignite, and P Shale. (Table 2.2.1a)

The first detailed stratigraphy of the Mae Moh basin has been proposed by Gardner (1967). He measured and described a type section of the Mae Moh Tertiary rocks using data from outcrops and boreholes. He named Mae Moh Formation (formerly spelled Mae Mo Formation) which was further subdivided, using alphabetical sequence following similar to sequence of Gloe (1955), into 11 beds, namely, Unexposed, L claystone bed, L lignite bed, M claystone bed, M lignite bed, N claystone bed, N lignite bed, O claystone bed, O lignite bed, P claystone bed, and concealed in ascending order. The thickness of the Mae Moh Formation was also estimated and reported to be 937 metres.

Table 2.2.1.a Comparative stratigraphic classification of the Mae Moh Basin by previous works.



The term "Mae Mo Group" (Recently spelled Mae Moh Group) is named by Piyasin (1971) to describe the Tertiary rocks in northern Thailand. The name came from the Mae Moh lignite mine where the rocks of Tertiary are well exposed and best recognized.

As oil price increases after the energy crisis in 1973, the alternative energy resources have become more concerned. Utilization of lignite as a source of energy for electrical generation is a promising alternative. As aforementioned situation, the proposal to assess the quality and quantity of lignite within the Mae Moh basin was jointly carried out between EGAT. and Longworth CMPS Engineers in 1979. As a result of this project, Longworth CMPS Engineers (1981) divided and described the stratigraphic sequence within the Mae Moh basin using general term, from top to bottom, namely, surficial gravels and alluvium , Red beds, Grey claystone, Upper lignite seam "K", Interburden-grey claystone, Lower lignite seam "Q", and Grey claystone. The maximum thickness of the Mae Moh stratigraphic sequence is estimated to be 1,030 metres. Besides, the seismic section N 13 which records a depth to basement of some 650 milliseconds, which is equivalent to the approximate depth of 870 metres in the vicinity of W 15. It is noted that the deepest hole drilled was about 560 metres at grid N5 W13, which only penetrated to the base of the bottom of "Q" seam (referred to this study as B - 2 Member).

It is interesting to note that the term Mae Moh Tertiary Sediments of Gloe (1955) and Sithiprasasna (1959), Mae Moh Formation of Gardner (1967), and Tertiary sequence of Longworth CMPS Engineers (1981) only described and covered claystone and lignite which can be compared or equivalent to the Mae Moh Group of this present study as "B

Formation"

Recently, the project so-called "Australian Development Assistant Bureau" (ADAB.) currently carries out the future development plan of the Mae Moh lignite Mine. ADAB. (inpreparation) has divided the stratigraphy within the Mae Moh basin into zones as shown in Table 2.2.1a.

The designation of the rocks as a group requires that major subdivisions in the group have formation rank. The hierarchy of formal lithostratigraphic units includes group, formation, member, and bed. In line with the findings of the present investigation, several changes are proposed which require the designation of new formations, members, and beds.

2.2.2 Geometry of the basin

The Mae Moh Tertiary basin is roughly triangular elongate trending in NNE/SSW direction. The basin does not close off in the south and the Tertiary sequence continue beneath a relatively younger basalt capping.

The result from the seismic lines, in association with some drilling results, the Mae Moh basin consists of four separated sub-basins, namely, main sub-basin, northern sub-basin,western sub-basin, and southern sub-basin, three sub-basins of which are separated by a structural high, and the last is considered as possible sub-basin. There are as follows:

a) The main sub-basin contains significant occurrences of lignite within a roughly rectangular area, defined by grid lines S 30

to N'46, and W 0 to W 35. The area of the main sub-basin is chosen for detailed study in the present thesis because almost all of EGAT. investigation were conducted within this area. The seismic basement profile of the study area is shown in Figure 2.2.2 a.

b) The northern sub-basin appears to be a northward continuation of the main sub-basin, but sediments were deposited on a relatively shallow and flat area, up to the north of grid line N' 46. Approximate 41 boreholes have been drilled to check the response of the seismic reflector bands followed by geophysical logging. There is no evidence of economic lignite deposit. Generally, the seismic reflector bands indicate either the boundaries between red clay and gray carbonaceous shale, or thin isolated seam of lignite and ligneous clay.

c) The western sub-basin, which lies to the west of the main sub-basin, is separated from other sub-basins by a structural high located near grid line W 30 - W 35. This sub-basin is relatively deep as illustrated by the seismic profile lines N'46, N 30 and N 13.

d) One possible sub-basin, so-called the southern sub-basin, is located south of grid line S 30 and includes the Tertiary strata beneath the basalt cap. These Tertiary strata are shown clearly on seismic section line W 23. Borehole data indicates that there is some lignite deposits underneath the basalt cap to the south of the study area.

2.3 Structural features in the neighbourhood of the study area.

Generally, the major structural trend in the neighbourhood of the study area lies approximately in the northeast - southwest

Slightly modified after Longworth CMPS Engineers, 1981

Sedimentological Studies of Some Tertiary Deposits of Mae Moh Basin, Changwat Lampang	Basement Profiles of the Study Area
Pol Chaolumrung, Department of Geology, Graduate School, Chulalongkorn University, 1985	Fig. 2.2.2a

direction. This trend is a part of the regional trend in northern Thailand which swings in a curved - or "S - shape" concaving northwesterly toward Changwat Chiang Mai. Further north of the study area, in the areas of Pha Yao and Wiang Pa Pao the structural trend changes it's direction into north-south, in Changwat Chiang Rai area it swings back to the northeast - southwest again. The shape of the intermontane Tertiary basins in the north are slightly conformable to this regional trend. However, the mechanism which created this regional trend are uncertained.

2.3.1 Faultings

In the vicinity of the study area, faults are generally oriented in the northeast - southwest and the NNE/SSW directions. The trend of fault is normally conformable with the orientation of the mountain ranges (Figures 2.3.1 a and 2.3.1 b.). Some of these are sinistral type at Doi Huai Nam Rin, Doi Nok, Doi Pha Chi and dislocated the rocks of Lampang Group as well as Pha Daeng Formation. The western flank of Mae Moh basin is fault - bounded, the northeast-southwest trending fault cutting by the approximate north - south trending fault (Figure 2.1 a). In the study area, late Cenozoic faults are reported by Longworth CMPS Engineers (1981). The report was based on sparse surface exposures, high resolution reflection seismic profile and several geological sections. The middle of the study area is a graben of about 1.5 kilometres wide, trending approximately in the NNE/SSW direction, and bounded on eastern and western sides by major fault zones each of which has a total throw of more than 200 metres along much of its length. Few faults have been detected within the graben, but many faults with throws ranging from

GEOLOGICAL MAP OF MAE MOH BASIN AND ADJACENT AREA

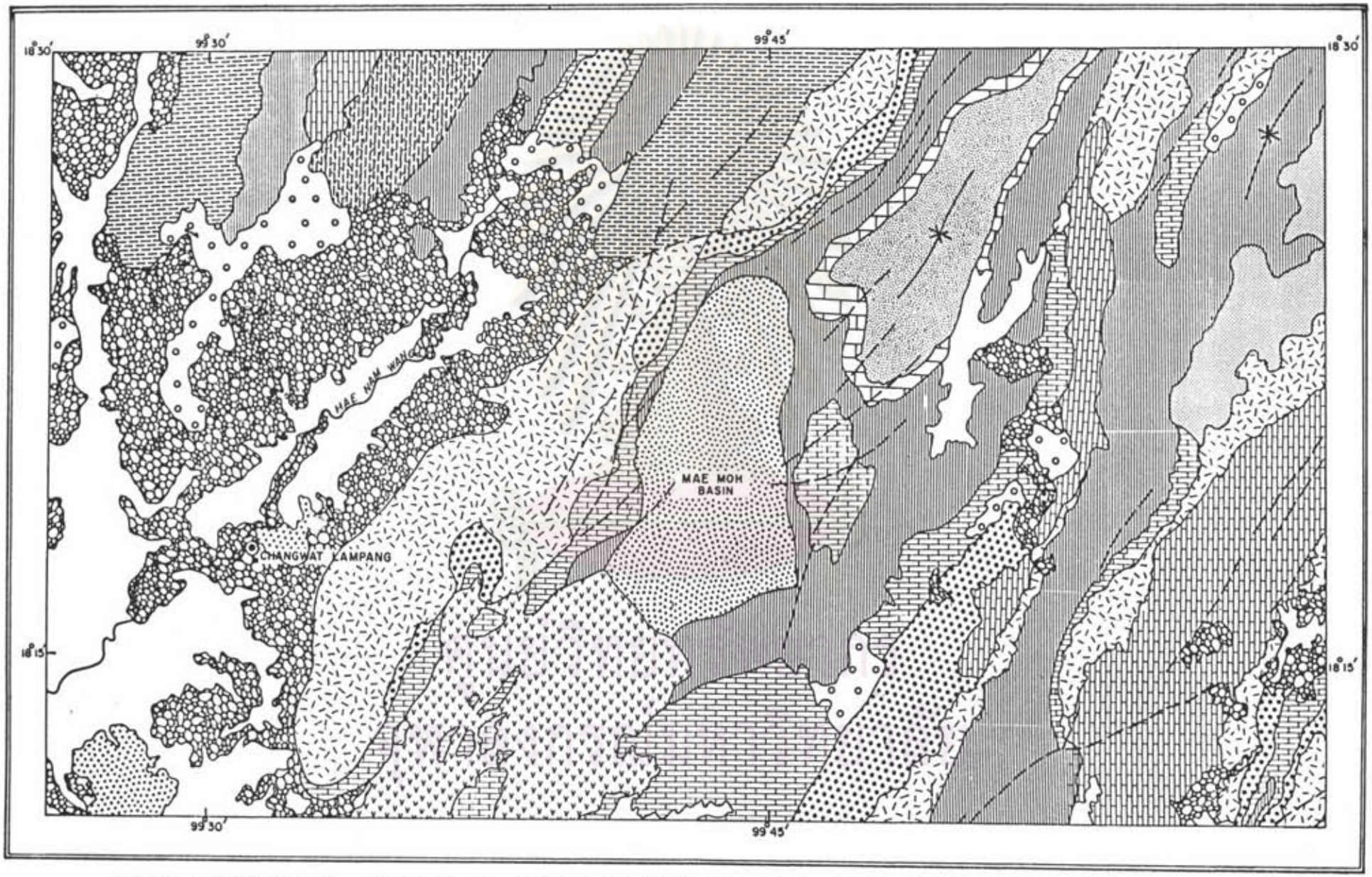


Fig. 2.3.1a Geological Map of Mae Moh basin and Adjacent Area (modified after Piyasin, 1972, Chonglakmani, 1981)

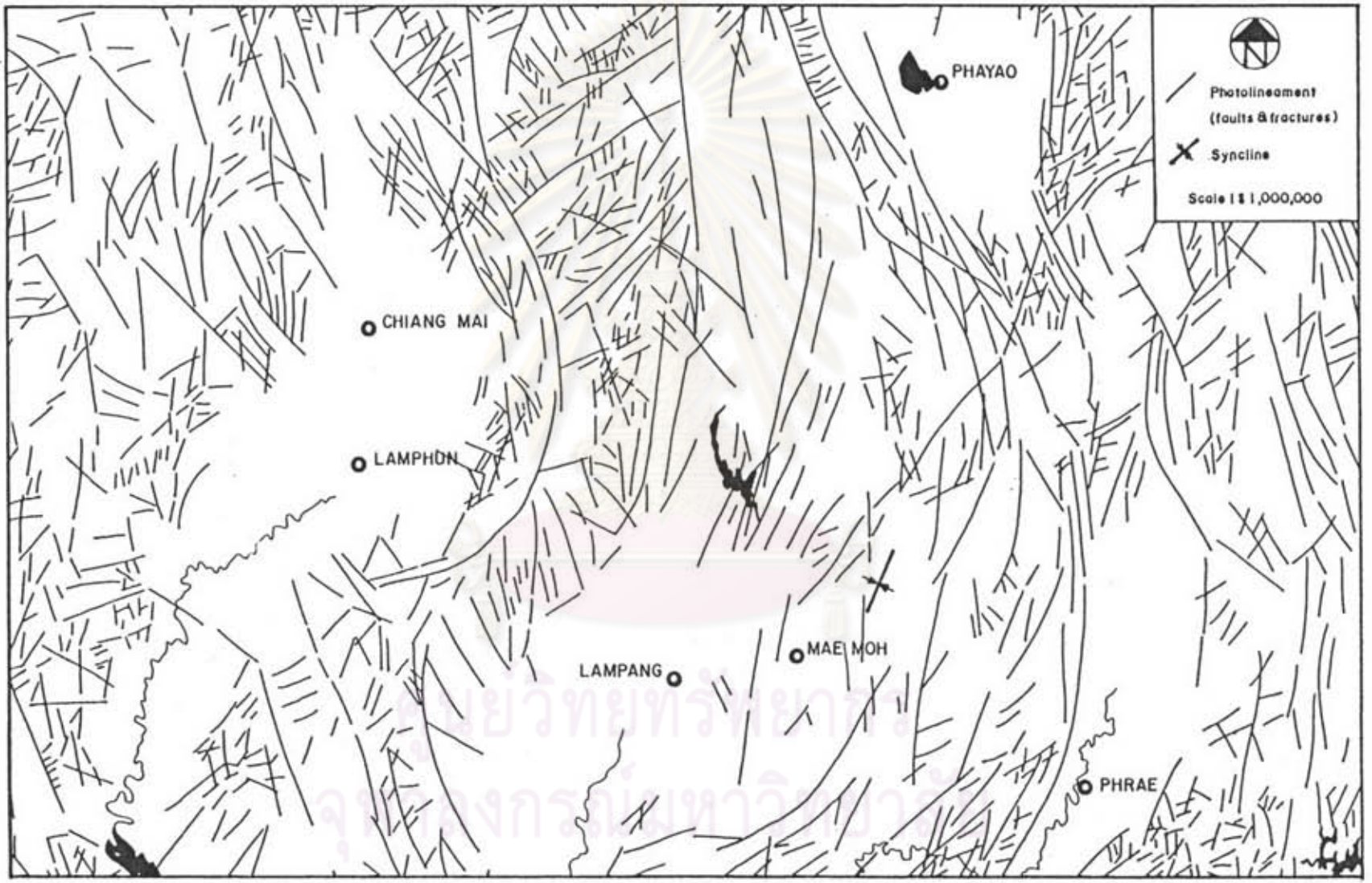


Fig 2.3.1bPhotolineament and Folding Map of the Study Area (After Aramprayoon , 1981)

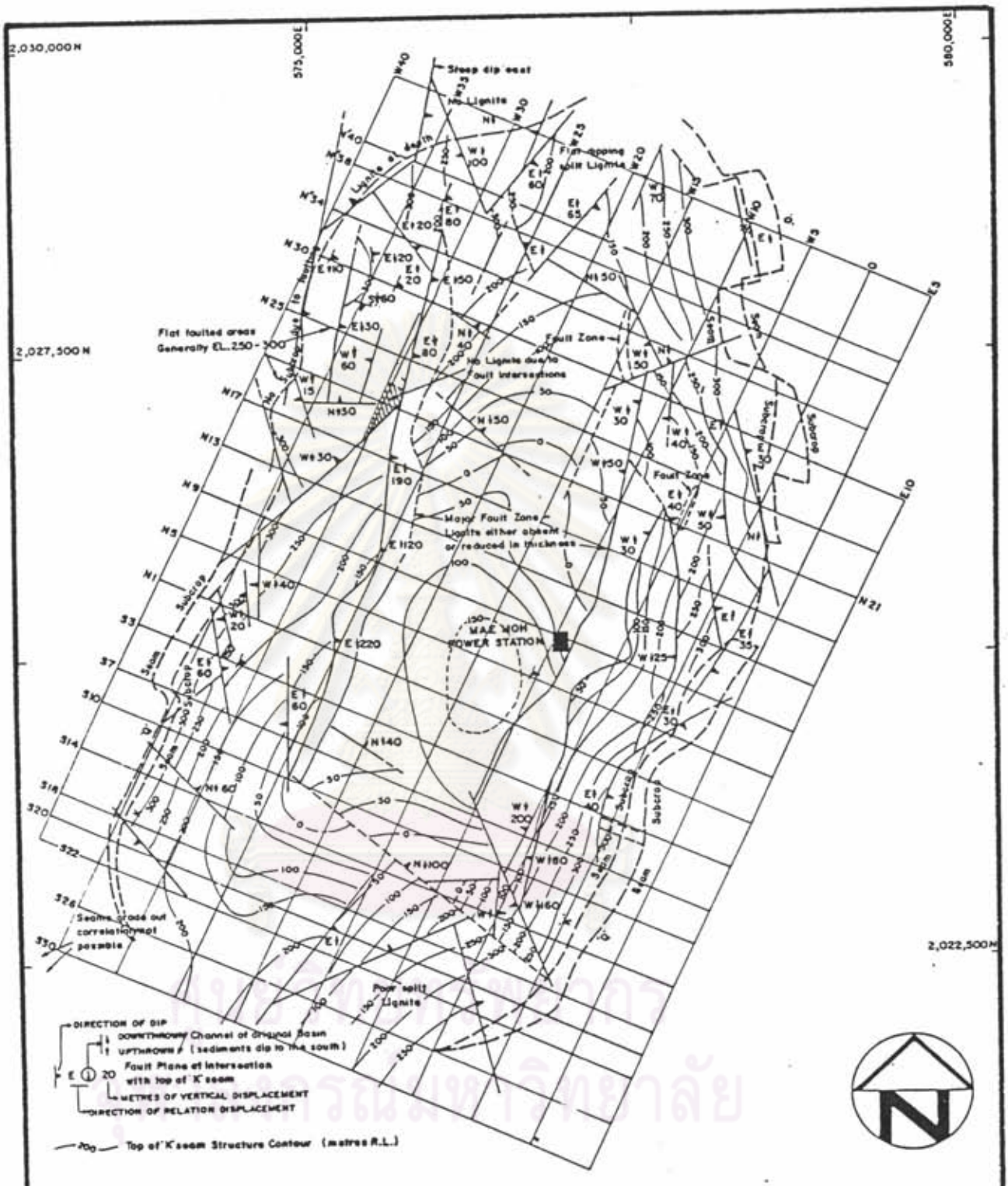
10 to 60 metres have been mapped in the bordering area up 1 kilometre wide (Figure 2.3.1 c). Almost all of these faults are normal type, few reversed faults are also reported (Longworth CMPS Engineers, 1981; Tandicul, 1983) with vertical displacements up to 40 metres. Vella (1983) suggested that these reversed faults appear to be surficial structure caused by gravitydriven collapse of the weakly consolidated Tertiary strata from the uplifted eastern side towards the centre of the basin. In addition, based on the fault map of Longworth CMPS Engineers (1981) coupled with the selected boreholes and the geological sections as well as the seismic profiles, the evolution of some faults have been evaluated in this study.

2.3.2 Foldings

Foldings in the vicinity of the study area are found in two zones on the eastern part, one is the obvious synclinal structure of Pha Daeng Formation at Doi Pha Daeng, and the other is anticlinal structure of Doi Chang Formation at Doi Pha Chi and Doi Pha Tup. It is also noted that the area underlying Mae Moh Tertiary strata is probably folded as synclinal structure based on evidence of the presence of Hong Hoi Formation as basinal basement rocks at borehole no. LM 2813S.

2.3.3 Unconformities

Generally, the Tertiary strata in Northern Thailand overlies unconformably on the pre-Tertiary rocks and underlies unconformably the surficial unconsolidated sediments of the so-called "Mae Taeng" Group. Late Middle Miocene unconformity is reported to occur widespreadly elsewhere in the Gulf of Thailand, Chao Phraya basin, Phitsanulok



After Longworth CMPS Engineers, 1981

Sedimentological Studies of Some Tertiary Deposits of Mae Moh Basin, Changwat Lampang	Structural Contour on Top of Member B-4
Pol Chaodumrong , Department of Geology Graduate School , Chulalongkorn University , 1985.	Fig. 2.3.1c

basin and the Sundaland area of southeast Asia. In the study area, Mae Moh Group is subdivided into 3 formations,namely, A,B, and C Formations in ascending order. It is noted that the C - Formation overlies both conformably and unconformably on the B-Formation. Although, the age of the C-Formation is uncertain, this unconformity is probably younger than Late Middle Miocene.

2.4 Geological evolution during Cenozoic time in northern Thailand.

After the late Triassic collision of Shan-Thai, Indochina and South China microcontinents, these microcontinents were welded and undergone little change during the Jurassic and early Cretaceous (Bunopas, 1981). A permanent attachments of continental crust occured through complicated crustal deformations and mountain building. The term "suture" is used to describe this complicated attachment process (Bolt, 1980). When the collision was extinct, tensional tectonic regime should occur and create normal faults or block faults which deposited of late Triassic to Cretaceous sediments. This collision is considered to be a part of the Indosinian orogeny which terminated the marine deposition on Thailand almost permanently. Therefore, most depositions are continental clastic sediments with minor small marine deposited locally. Jurassic and Cretaceous tectonism was mainly sinistral strain manifested by northwest-southeast trending of the Mae Ping and Three Pagodas strike slip faults which are subparallel to the Red River strike-slip fault of which appears to be dextral at present. The tin bearing Cretaceous granites forming a belt subparallel to, and partly overlapping with the tin bearing granites of the late Triassic-early Jurassic belt which extendings through Burma, west Thailand, the Malay Peninsular and northwest Indonesia (Suensilpong et al.,1979; Bunopas, 1983). The Mae Ping and

Three Pagodas faults ceased moving late in the Cretaceous or early in the Tertiary. These sinistral strike-slip faults dislocate the main geological province of Thailand and their trends have been modified by sinistral oroclinal bending that appears to be associated with the strike-slip fault (Bunopas and Vella, 1983) (Figure 2.4 a). During Cretaceous to Present time, India plate was drifted toward the north. Although, the time of collision between the India and the Eurasia plates which resulted in the uplift of Himalaya mountains is still Controversy. Curray and Moore (1974) in Suensilpong et al. (1979) proposed that they took place in late Paleocene time or approximately 55 million years ago, while Molnar and Tapponier (1980) believed to be about 40 million years. According to the northward drift of the Indian plate which resulted in subduction along the eastern margin of the present Bay of Bengal, opening of the Andaman Sea, initiation of Andaman-Nicobar chain , and opening of the Indian Ocean (Tanasithipitak,1979; Bunopas and Vella, 1980). However, Bunopas (1983) proposed that the tin-bearing Cretaceous granites were probably resulted from this phase of subduction. The effects of the Himalayan Orogeny on Indosinian were in the form of broad regional folding and block faulting. It was probably during the late stage of tectonic activity, in Paleocene or early Eocene, that the emplacement of Tertiary granite took place. This phase of granite eruptive can be regarded as post orogenic and is generally found as dikes, stocks, or sub-batholiths superimposed on the pre-existing granites (Suensilpong et al.,1979).

According to Bunopas and Vella (1983), Bunopas (1983),a tensional regime developed during the Tertiary and a system of north-south trending normal fault appeared. The faults are nearly parallel to the present day

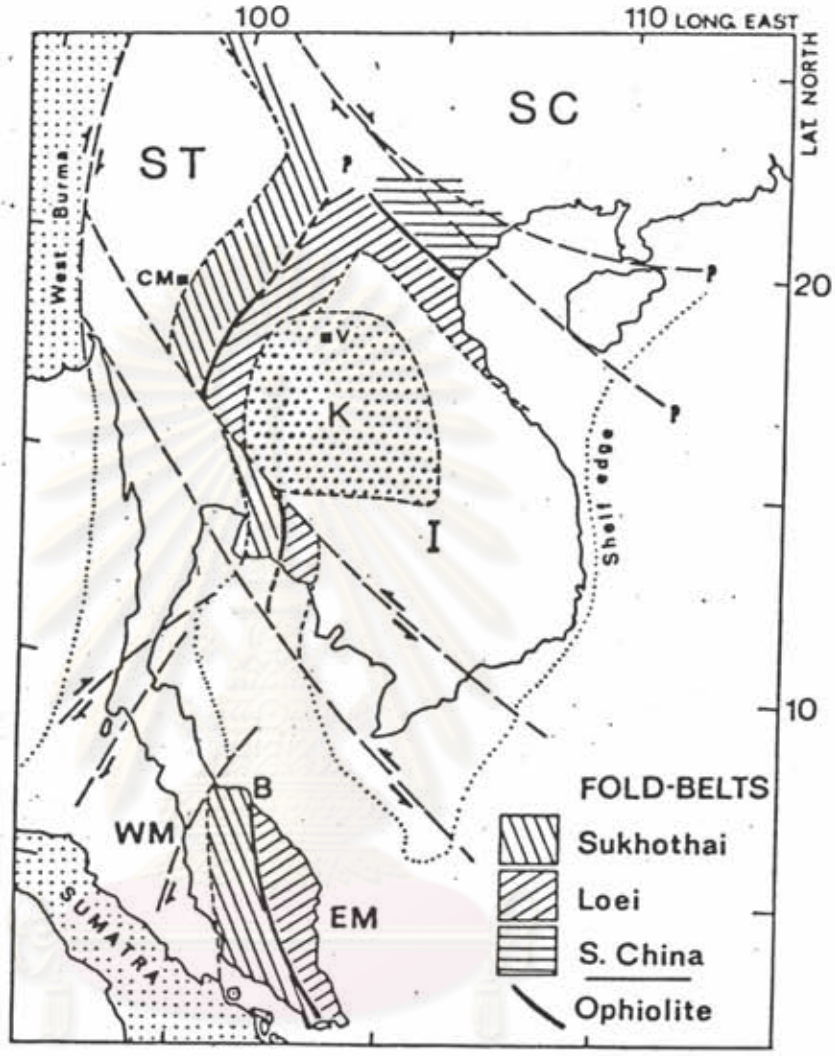


Fig. 2.4a Ancient cratonic areas; I, Indochina (including eastern Thailand); SC, South China and ST, Shan-Thai (eastern Burma, western Thailand and Northwestern Malay Peninsula). Adjacent fold-belts are formed of thick mainly marine Paleozoic to Triassic sediments and tholeitic volcanic rocks that accumulated along the margins of the cratons. Ophiolites lie between contiguous fold belts. Sinistral faulting and oroclinal bending occurred mainly during the Jurassic and Cretaceous. K, Khorat Basin; CM, Chiangmai; V, Vientiane; WM, West Malay Peninsula; EM, East Malay Peninsula; B, Bentong ophiolite line.

(after Bunopas, 1981)

motion of oceanic crust decending beneath indonesia along the Java Trench. Tension was probably started in the south with the opening of the Gulf of Thailand where many north-south trending faults have been revealed by seismic surveys and they have moved continuously during the deposition of sediments, Besides, these faults extend northwardly into northern Thailand, Burma and Laos. Rifting was east-west,at right angles to the trend of the normal faults.

The Cenozoic basins of Thailand was probably initiated on an eroded pre-Tertiary surface with varying degrees of topographic expression (Knox and Wakefield, 1983). During Lower to Middle Miocene, widespead development of lacustrine facies was established in the onshore basin of Thailand. Prominent unconformities in the central basin and some onland Tertiary basins are the Pleistocene-Pliocene and late middle Miocene unconformity (Chaodumrong et al., 1983). In the Phitsanulok basin the coincidence of a basaltic lava with the unconformity dated as 10.3 ± 0.2 million years by K/Ar radiometric age (Knox and Walkefield, 1983). Other onland basalt which is found on Ko Kut Island, eastern Gulf of Thailand, dated as 8.5 ± 1 million years (Bignell and Snelling, 1977). The unconformity appears to represent a major episode of uplift which followed by an influx of coarse to fine clastic sediments.

Late Tertiary to early Quaternary basalts were widely distributed in northern, central and southeastern parts of Thailand. Judging from the fact that basalt is overlying on the gravel bed at Nam Mae Jang in the north, the attitude and ground elevation of gravel bed at present time, and according to Baum et al. (1970), the late Tertiary and/or Pleistocene normal faulting and uplift determined the present day topography of northern Thailand.