CHAPTER 1

INTRODUCTION

Petroleum provinces in Thailand can be geographically separated into six regions, the Northern Thailand, the Central Plain, the Northeastern Thailand, Southern Thailand, The Gulf of Thailand and the Andaman Sea. Petroliferous basins are mostly Tertiary in age and distributed in various parts of the country, both onshore and offshore. Ten Tertiary basins are assured their petroleum systems to yield commercial hydrocarbon accumulation. Pre-Tertiary basin located in the northeast is made up of sedimentary rocks dating from Carboniferous to Tertiary. Hydrocarbon deposits have been found and currently produced from Permian strata.

In northern Thailand, Fang basin is only one of petroleum producing basin among the Tertiary intermontane basins which are north south trending structure relationship between conjugate strike-slip faults and development of north south trending pull-apart basins (Polachan *et al.*, 1991).

According to previous studies, Lampang Tertiary basin has good reservoir quality and evidence of petroleum is produced from fluvio-lacustrine sandstones in Fang basin as above mention, we are interested in studying reservoir properties of the pre-Tertiary outcrop in Lampang basin.

From well known reservoir rocks, sandstone and carbonate, we are more interested in carbonate rock that does not produce hydrocarbon yet in northern

intermontane basin. Therefore we selected the carbonate outcrop in Lampang basin to study its stratigraphy and reservoir properties.

Triassic sedimentary rocks in Thailand are exposed in four main areas in the north (Lampang-Phrae-Nan), west (Kanchanaburi-Mae Sariang), south (Phang Nga-Songkhla) east (Chanthaburi-Trat), (Fig. 1.1). Among them the north area, particularly in the Lampang and Phrae provinces has the best exposure in the country due to two highways which cross-cut nearly normal to structural trend. The Triassic sequences in this area have been folded and faulted during the late Mesozoic and Cenozoic Eras, resulting in complex geological structures, steep dips and "S-shaped" structural trends. The rocks were first examined by Pitakpaivan (1955) and named the Lampang Group by Piyasin (1971 and 1972), during his compilation of the regional geological map. Many attempts to investigate the geology of this central north area have been made because it is key area in discussion of the continent-continent collision between the Shan-Thai and Indochina terranes.

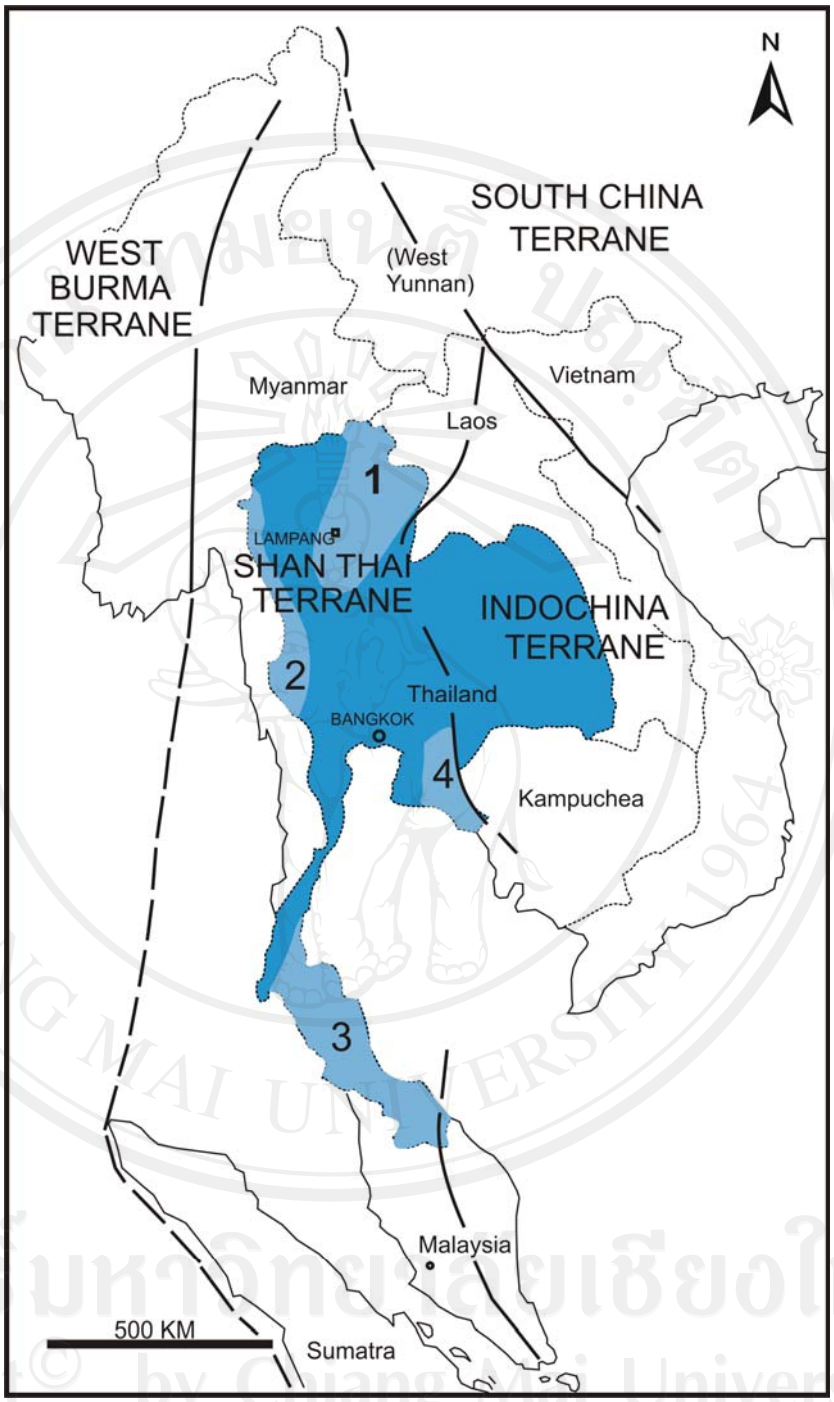

Figure 1.1 Map showing major distribution of Triassic rocks in Thailand, the terrane boundaries of Shan-Thai and Indochina, and their adjacent terranes 1 = Lampang – Phrae – Nan area, 2 = Kanchanaburi – Mae Sariang area, 3 = Phang Nga – Songkhla area and 4 = Chanthaburi – Trat area (after Chaodumrong, 1992).

1.1 Physiography and Regional Geology

1.1.1 Physiography

Northern Thailand consists mainly of intermontane basins created by block faulting during the Cenozoic Era. As a result, almost low-lying or intermontane basin areas were covered by Cenozoic sediments and all pre-Tertiary rocks including igneous rocks are exposed in mountainous areas. Central northern Thailand consists of two main subparallel Cenozoic basins running in an approximately NNE-SSW direction parallel to structural mountain trends that were oroclinally bent.

The central north of Thailand belongs to the tropical savanna area characterized by three seasons. Winter with temperature at night below 10˚ C, lasts from November to February. Summer covers the months of March through to June with temperature during the day reaching 40˚ C. The rainy season, due to the southwest monsoon, occurs from July to October.

1.1.2 Regional Geology

The study area is located in Lampang province and in the Sukhothai fold belt of the Shan-Thai terrane (Fig. 1.1). This terrane is west of the Nan Suture Zone which was created by continent-continent collision with the Indochina terrane to the east (Bunopas, 1981; Hahn *et al*., 1986; and Panjasawatwong, 1991). Structural trend lie approximately North-South direction that were oroclinally bent and folded, probably during Cretaceous and Paleogene Periods. The rocks were also faulted in the Cenozoic.

The oldest rocks in the central north Thailand are called the Siliuran-Devonian Donchai Group (Piyasin, 1972). They consists of low grade metamorphic rocks (green

schist facies), i.e.,phyllite, quartzo-feldspathic schist, chloritic phyllite, calcsilicate phyllite and slate. The Silurian-Devonian age of the Donchai Group was determined from its stratigraphic position below the Permian Ngao Group and the inferred Carboniferous Mae Tha Group (Piyasin, 1972; Bunopas, 1981) and also from the degree of metamorphism and deformation which in Donchai Group are higher than in the overlying strata.

The Triassic Lampang Group formed in 2 adjacent sub-basins that contain similar lithology and lithologic sequences but are different in age (Fig. 1.2). It uncomfortably overlies "Permo-Triassic volcanic rocks". It both conformably and uncomfortably overlies and underlies the Permian strata and the inferred Jurassic red beds, respectively. The overlying conformable contact occurs mainly in the central area of younger depositional basin, particularly in the area east of Ngao and Phayao (Hahn *et al*., 1986; Chonglakmani and Kenvised, 1986). Ages for all red beds are poorly known. Most are suggested on the basis of their stratigraphic position. Another major unconformity developed during the Cretaceous to middle Tertiary interval, and no Cretaceous to middle Tertiary fossils have been found in this area. The youngest unconformity is commonly placed at the inferred Tertiary-Quaternary.

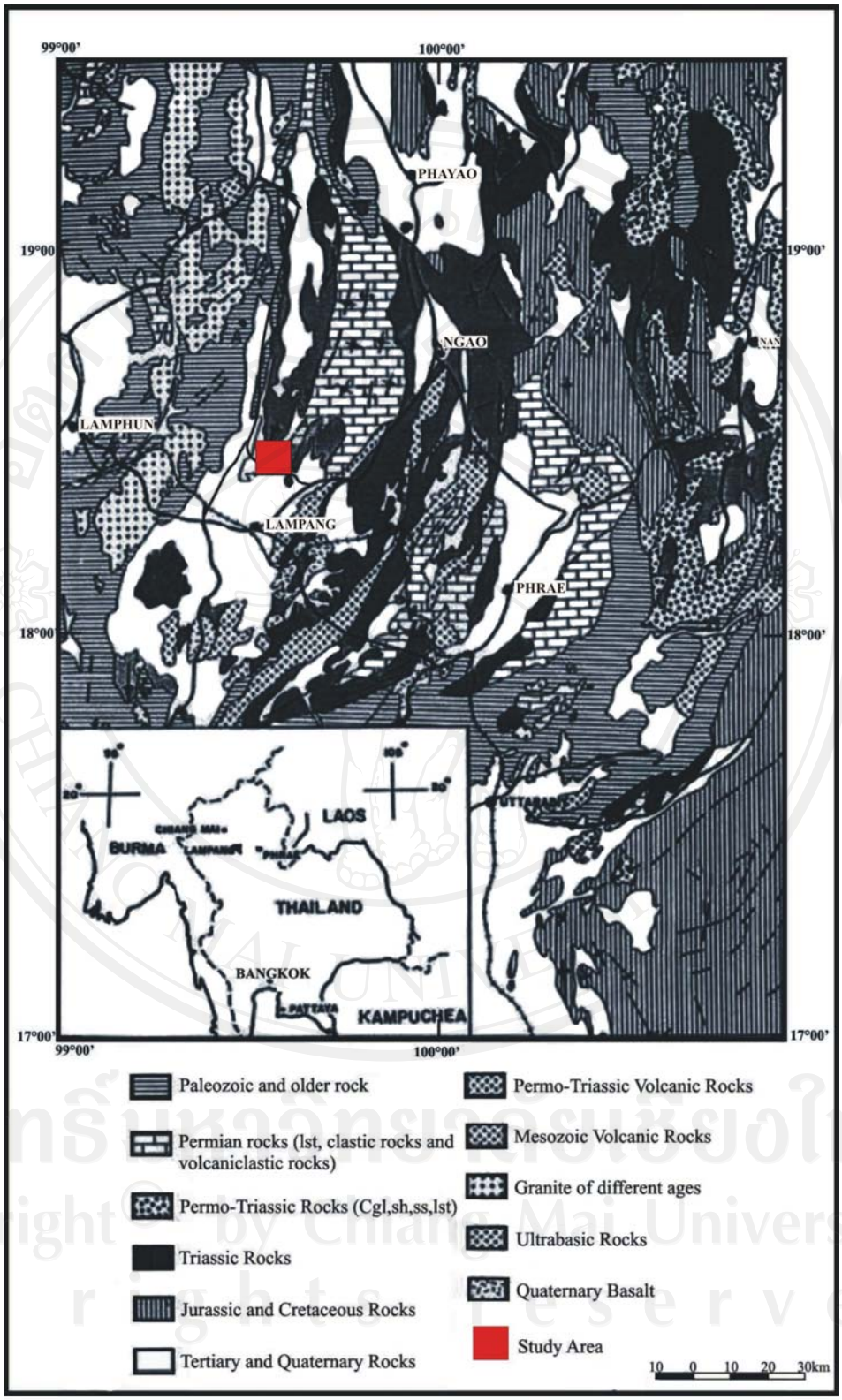

Figure 1.2 Simplified regional geology map of central north Thailand showing the studying area (after Piyasin, 1972; Baum and Hahn, 1977).

1.2 The objective of study

The objective of this study was to interpret the depositional environment and reservoir properties of selected outcrop, where located at km 26 of road number 1335 or at grid reference 658582 of Topographic map, scale 1:50,000, sheet 4946 III, series L7018, 1999, edition 1-RSTD, Triassic rocks in Ban Phai Phae, Chae Hom district, Lampang province, northern Thailand (Fig. 1.3) by using facies analysis concept in a sequence stratigraphic framework based on lithologic columns, petrography of thin sections. This study was expected to improve the better understanding of lithofacies and reservoir properties of each facies within the interval relating to depositional environment. Facies descriptions include lithology, thickness, color, composition, grain characteristics, bedding characteristics, sedimentary structures, nature of overlying and underlying contacts, trace and body fossils. Facies descriptions are followed by discussion of depositional process and environments.

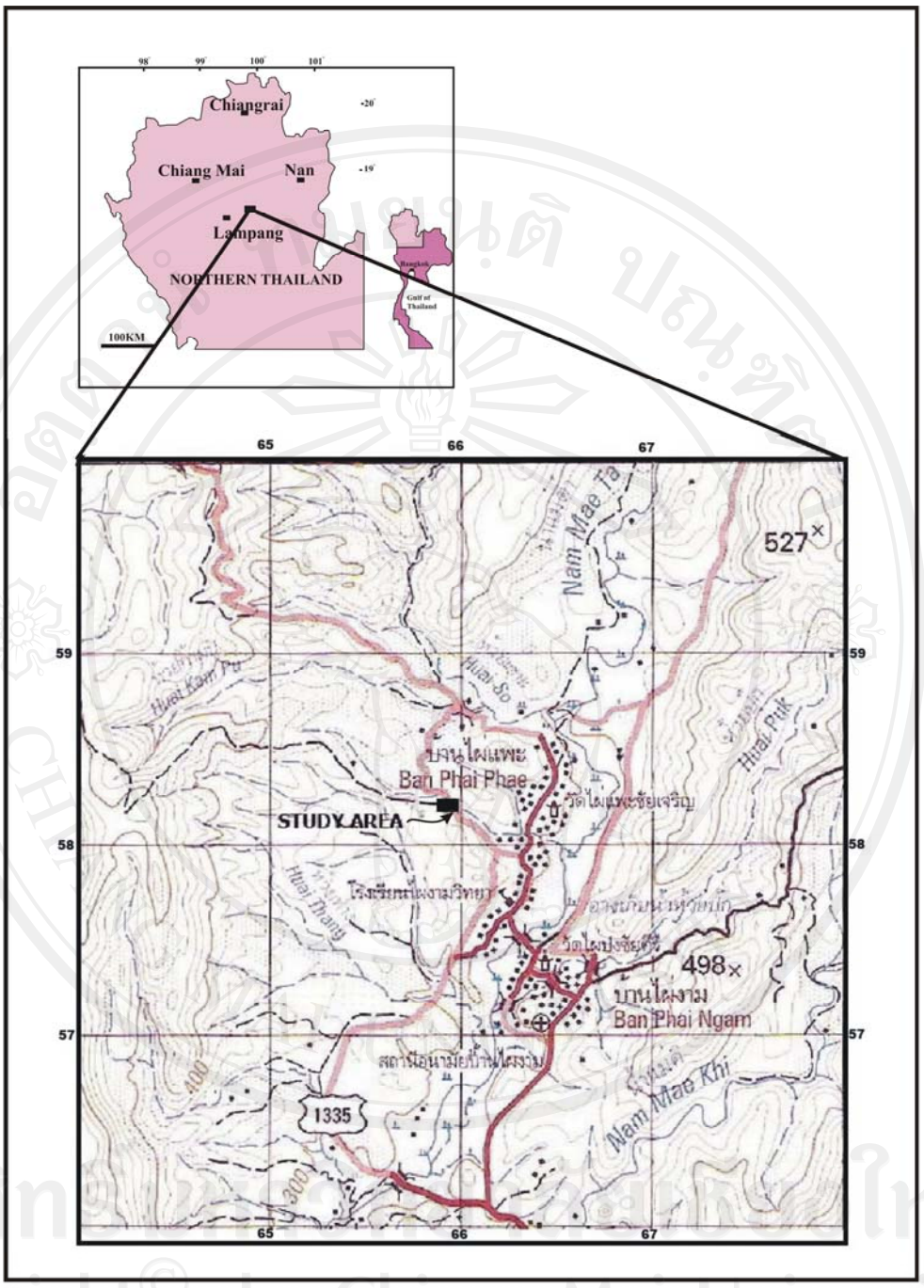

Figure 1.3 Location map of study area at grid reference 658582 of sheet 4946 III series 7018 or km 26 of Road 1335, located western area of Ban Phai Phae, Chae Hom district, Lampang province, northern Thailand (modified after Topographic map, scale 1:50,000, sheet 4946 III, series L7018, 1999, edition 1-RSTD).

1.3 Previous studies

1.3.1 Stratigraphy of Lampang Group

It is well known that the sedimentary sequences of the Triassic Lampang Group in central north Thailand, particularly in the Lampang and Phrae areas, are similar, consisting of clastic and non-clastic sequence with red beds and limestones (Piyasin, 1972, 1975; Baum and Hahn, 1977). However, their ages are very different; those in Phrae area being younger (Chonglakmanini, 1981). There are two sharply contracting lithostratigraphic classification in existence (Table 1.1). One scheme includes the strata in Lampang and Phrae areas in the same lithographic unit, according to the assumption of Piyasin (1972) and Chonglakmani (1981) that these strata were deposited in the same depositional cycle (Charoenpravat *et al*., 1986; Sukvattananunt and Paksamut, 1986; Wolfart, 1987; Charoenpravat *et al*., 1987), however, the terminologies of Piyasin (1972) and Chonglakmani (1981) are dissimilar. The other scheme is new and considers the sedimentary sequence in the Phrae area as a separate younger depositional cycle lying on that in the Lampang area (Chonglakmani and Kenvised, 1987a, b).

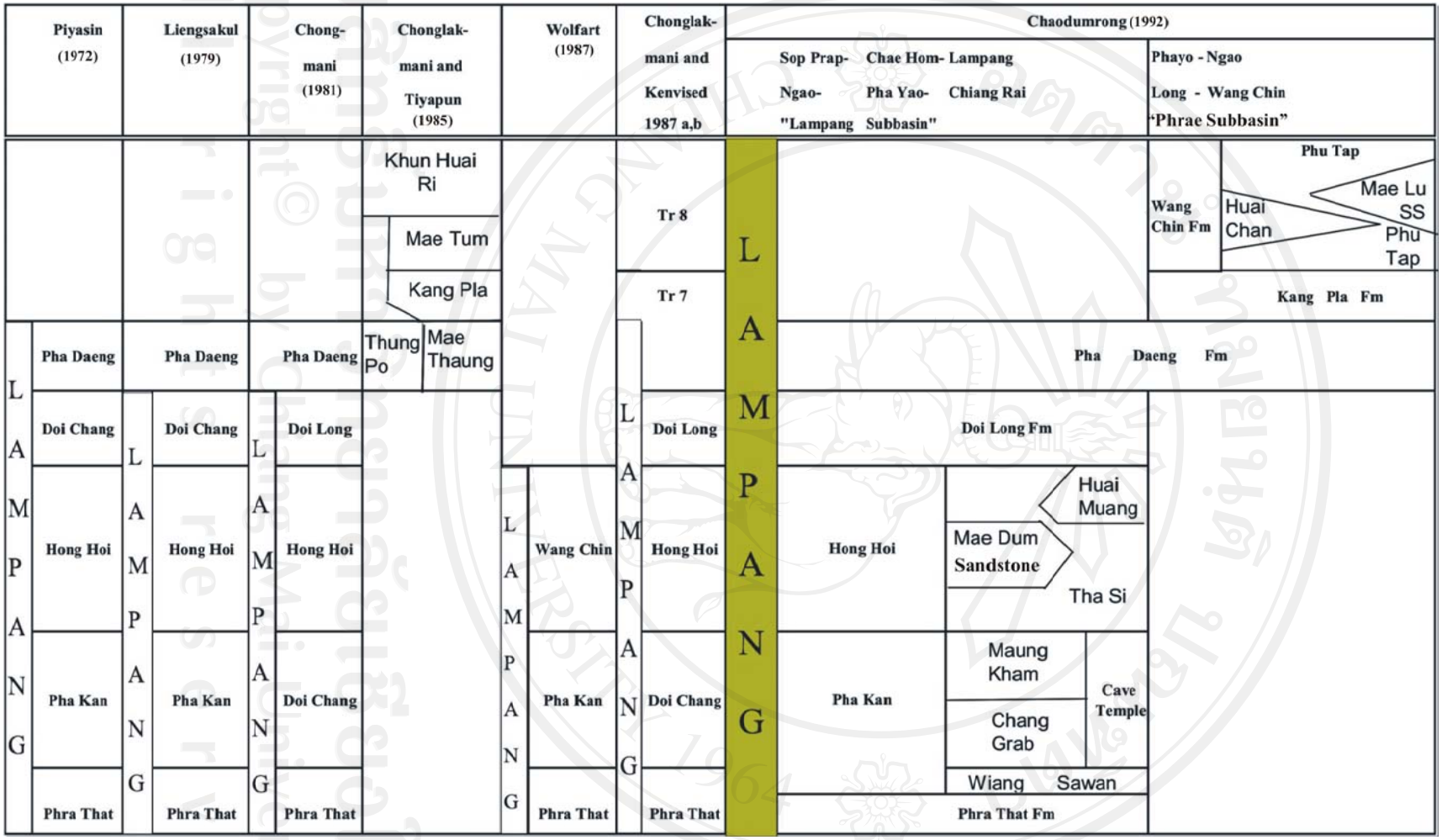

Table 1.1 lithostratigraphic nomenclature of Lampang Group of Thailand (modified after Chaodumrong, 1992).

1.3.2 Sedimentology of the Lampang Group

The shallow carbonate platform was widely suggested for the Lampang carbonate based mainly on an occurrence of abundant oncolites and some oolites (Piyasin, 1972; Chonglakmani, 1972, 1981; Bunopas, 1981; Helmcke, 1985), although the oncolites are mainly restricted to the Pha Kan Formation. Few oncolites are found in the younger Doi Long and Kang Pla Formations. Depositional environment of the Lampang carbonates are mainly shallow marine. However the carbonates formed in a variety of depositional environments which can be interpreted in terms of three depositional environment models, namely ramp, drowned ramp and regression platforms.

Mudstone and interbedded sandstones of the Hong Hoi and Wang Chin Formations have been interpreted in different ways: flysch and pelagic sediments (Chonglakmani, 1972, 1981), forearc sediments (Bunopas, 1981; Sengör, 1984), post-collisional sediments (Helcke, 1984; Chonglakmani and Helmcke, 1989) and neritic sediments (Hahn and Siebenhuner, 1982). Although these rocks are not identical to the "classional turbidite" (Walker, 1984) because they lack prominent flute structures on the basal Bouma sequence, they certainly formed by turbidity current; therefore they are turbidites. Turbidites can form in both shallow and deep water environments but they are not commonly preserved in shallow environments due to subsequent wave and current actions (Walker, 1984). The turbidites were deposited in submarine fan environments.

The stratigraphy and sedimentology show that the Lampang Group in the central north of Thailand formed in two adjacent basins; the Lampang sub-basin in the west and the Phrae sub-basin in the east. The Lampang sub-basin takes in the Sop

Prap, Lampang, Chae Hom, Wang Nua, Phayao and Chiang Rai areas, while the Phrae sub-basin takes in the Wang Chin, Phrae, Long, Song, Ngao, Phayao and Chiangrai areas. These two sub-basins are separated by the Doi Luang-Khun Khiat Range that consists of volcanics of possibly Permo-Triassic age (Fig. 1.4). Sediments and sedimentary sequences of these two sub-basins are strikingly similar, consisting mainly of red beds, platform carbonates and turbidites; but their ages are very different (Chaodumrong, 1992).

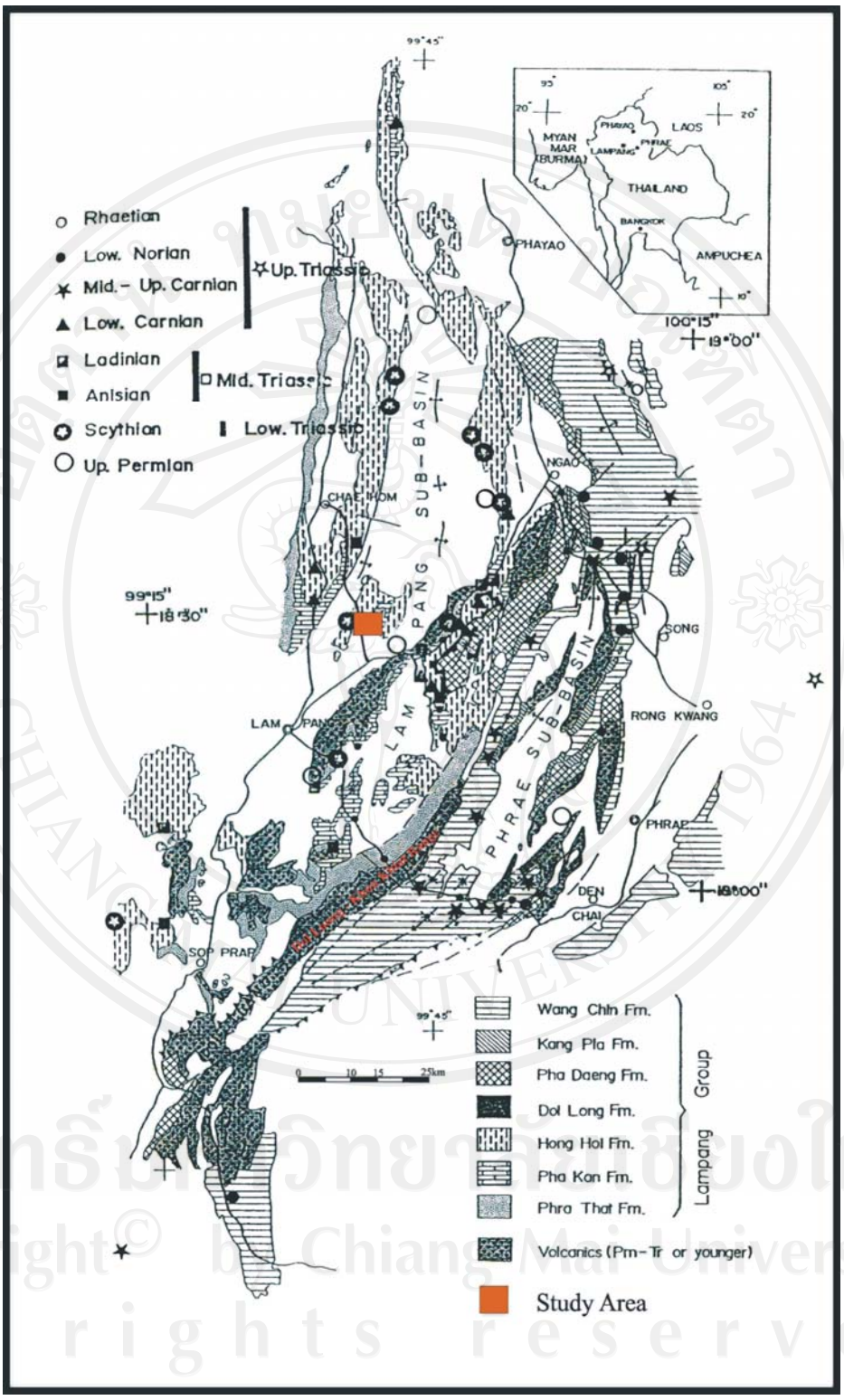

Figure 1.4 Geological map of Lampang Group in the central north Thailand showing the aerial distribution of the constituent formations (modified after Chaodumrong, 1992).

The Hong Hoi and Wang Chin formations mud-rich, gravity flow successions that form major parts of the Lampang Group. Both formations are similar in lithology and sequences, and consist mainly of mudstones, subordinates, unchannelized sandstones and minor conglomerates.

Although turbidites can occur in either shallow or deep water environments, combination of the cross stratification created by either tidal currents or storms, facies association and vertical sequence suggest submarine fans with detached sand bodies for most of the Hong Hoi and Wang Chin sediments. In some places, they also show a close association with shallow-water clastics.

1.4 Literature Review

The Triassic Lampang Group (Piyasin, 1972), previously divided into 5 formations then it has been revised into 7 formations by Chaodumrong (1992), namely, in ascending order, the Phra That, Pha Kan, Hong Hoi, Doi Long, Pha Daeng, Kang Pla, and Wang Chin Formations (Fig. 1.5). These lithostratigraphic units are composed mainly of mudstones, limestones, gray to greenish gray sandstones and subordinate conglomerates totally 5,000 meters thick. These rocks are unconformably underlain by the Permo-Triassic volcanics and are both unconformably and conformably underlain by Permian rocks. The unconformable contacts are mainly confined to the rim of the depositional basins. The Lampang Group is also both unconformably and conformably overlain by the Jurassic red beds. The conformable contracts are confined to the middle part of the depositional basin.

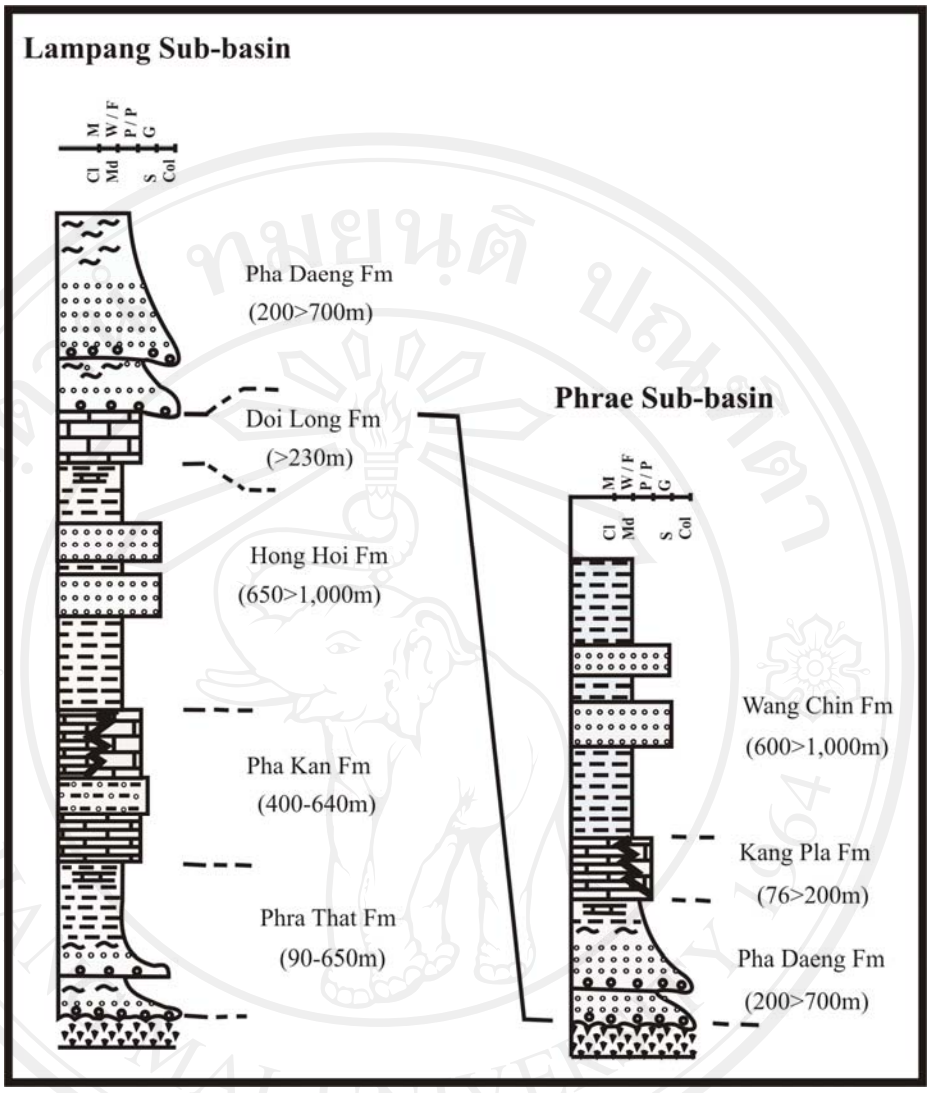

Figure 1.5 Generalized lithostratigraphy of the Lampang Group and thickness of the formations (modified after Chaodumrong, 1992)

The Hong Hoi Formation is generally lying between the limestone of the overlying Doi Long Formation and the underlying Pha Kan Formation. It consists mainly of fine grained turbidites, i.e., gray to greenish gray mudstone with subordinate sandstone, siltstone and minor limestone and conglomerate. Ammonoids *paratrachyceras* and bivalves *Posidonia* and *Daonella* are common in mudstone. The formation occurs in Lampang sub-basin and consists of three members: the Tha Si,

Mae Dum sandstone and Huai Muang (Fig. 1.6). The type locality of the formation is situated along the Huai Mae Dum and the Huai Muang.

1. Tha Si Member: Takes its name from Ban Tha Si and is characterized by mudstone and minor intercalated sandstone, conglomerate and limestone. Mudstone is gray to greenish gray and laminated or structureless, and commonly displays conchoidal fractures. The lamination was formed by interbedding of mudstone and laminated siltstone. Sandstone is thin to medium bedded, fine to coarse grained and often normally graded, and frequently contains feldspar and fossils wood fragments. Gravity flow sediments are present. This member exposed along the Lampang – Ngao (Phaholyothin) highway. Its upper boundary is taken as the base of a thick sandstone bed.

2. Mae Dum Sandstone Member: This takes its name from Huai Mae Dum where good exposure occurs. It is characterized by sandstone with alternating conglomerate and mudstone (Fig. 1.6). Thinning and fining upward sequences of sandstone bed occur in places, as do even and parallel interbedded sandstone and mudstone. Sandstone are gray, to massively bedded and medium to coarse grained; they often contain feldspar and fossils wood fragments, commonly display normally graded beds and usually show sharp contacts with the underlying mudstone. Flute structures are rare to absent. Lamination, ripples marks and cross stratification occurs locally in sandstone and siltstone. There are also rare channel structures. Conglomerates are both clast-supported and matrix-supported and clasts are made up only of volcanics and are in some cases, limestones. Mudstones are generally thin units, but can be thick and are interbedded with laminated to thin-bedded sandstone to siltstone, and fossils of ammonoids *Paratrachyceras* and the bivalves *Posidonia* sp.

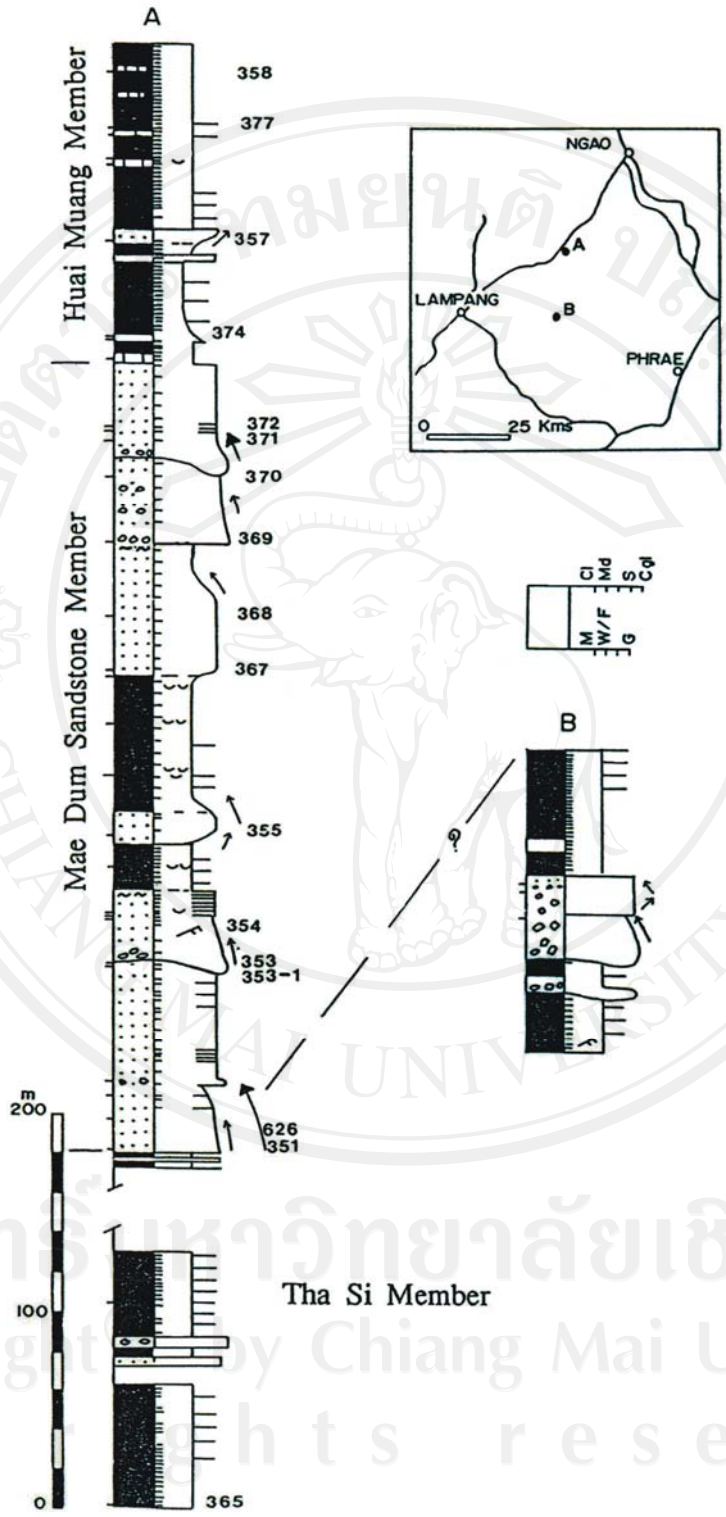

Figure 1.6 Lithostratigraphic log of Hong Hoi Formation (Chaodumrong, 1992).

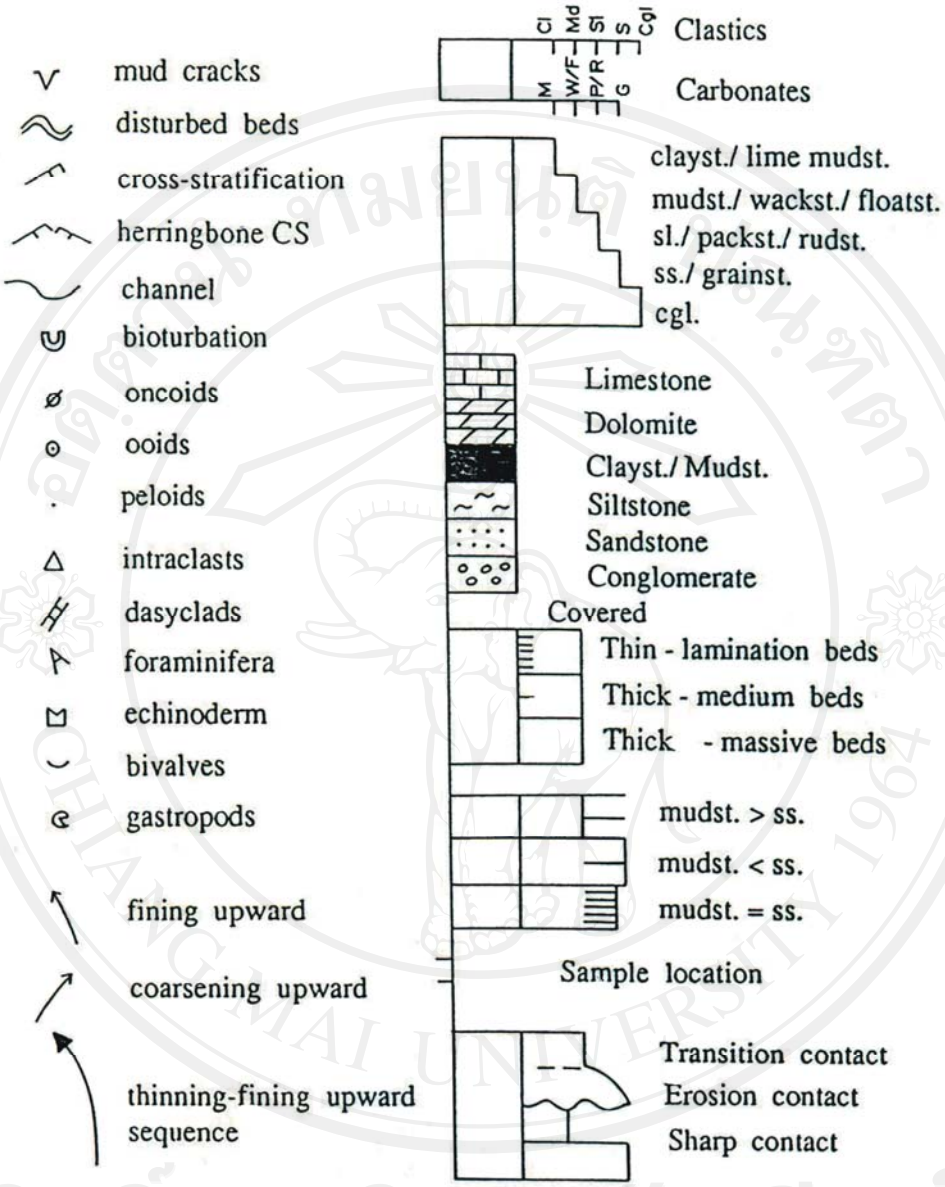

Figure 1.6 (continue) Key for stratigraphic symbol.

and *Daonella* sp. usually common. Uppers boundary of the number is taken as the base of the first overlying limestone bed.

3. Huai Muang Member: Its name is borrowed from Huai Muang where good rock exposures occur. It is characterized by mainly gray to greenish gray mudstone

and shale with interclation of limestone as beds or nodules and laminated siltstone. The proportion of limestones, commonly laminated, increases up the sequence. In thin section, limestones commonly contain thin-shelled fossils. The existence of this member may bear a close relationship with of the Doi Long Formation.

Thickness of the Hong Hoi Formation: A 700 meters thick sequence was measured in the Huai Mae Dum – Huai Muang section where the lower boundary of the formation is not seen. However the measured thickness differs markedly from previous estimates, i.e., 1200 meters by Piyasin (1972), and 1900 meters by Chonglakmani (1981).

Regional extent: The Hong Hoi Formation crops out mainly in two areas in the Lampang sub-basin. These are the Sop Prap-Chae Hom-Wang Nua and the Mae Tha-Mae Moh west of Ngao and Phayao areas, and it possibly extends to the Chiang Rai region.

Paleontology and age: The oldest rocks of the Hong Hoi Formation seem to occur in the central part of the elongated basin such as west of Ngao and Sop Parp areas and the sequence becomes younger towards the flank. The formation ranges from lowermost Triassic to lower Upper Triassic. According to Chonglakmani (1981), the *Claraia-Ophiceras* fauna, such as *Claraia stachei*, *Claraia concentrica*, of late Griesbachian age occur in Ban Bon west of Sop Parp, in Ban Huat west of Ngao and Huai Or Dong west of Mae Wang Dam. Lower Carnian fauna dominated by the ammonoids *Paratrachyceras* and bivalves *Daonella* and *Posidonia* occur in Ban Tha Si, Mae Moh and Chae Hom areas (Chonglakmani, 1981). *Sirenites senticosus*, a typical fossils of early Carnian age, is reported from northwest of Phayao province (Jordan, 1973). At Chae Hom district, Baum *et al*. (1970) reported the upper Scythian

conodonts, *Hadrodontina anceps* and *Paychycladinia symmetrica*, in the basal conglomerate of the Hong Hoi Formation.

Type locality: A good exposure of the Hong Hoi Formation crops out from Huai Mae Dum to Huai Muang northeast of Ban Tha Si, Mae Moh district, which is regarded as the type locality.