

## CHAPTER IV

### BIOSTRATIGRAPHY AND AGE

Interpretation of data from field works and laboratory perform the range of fusulinids and biozones of study area. The result of this study shows that Tak Fa formation in the area of Khao Wong and Khao Chakkachan, Amphoe Nong Muang, Changwat Lop Buri, consists of thirteen species in nine genera of the fusulinids, and can be sudevided into 5 biozones. It age is ranging from Middle Wordian to Middle Capitanian.

#### 4.1 Biostratigraphy of study area

The study area covers three hills belong to Tak Fa formation : Khao Wong, Khao Chakkachan, and Khao Wat Kirinakratanaram. The thirteen species of the fusulinids of nine genera are studied and described in this work. The following are the fusulinids of each hills of study area :

Khao Wong : *Colania douvillei* (Ozawa), *Sumatrina* cf. *longissima* (Deprat), *Metadololina nongmuangensis* sp. nov., *Chusenella* cf. *schwagerinaeformis* Sheng, *Pseudofusulina* sp. Dunbar and Skinner, and *Verbeekina verbeeki* (Geinitz).

Khao Chakkachan : *Neofusulinella lantenoisi* Deprat, *Neofusulinella* cf. *saraburiensis* Toriyama, Kanmera, and Ingavat, *Pseudodoliolina pseudolepida* Deprat, *Sumatrina annae* Volz, *Verbeekina verbeeki* (Geinitz), *Parafusulina gigantea* (Deprat), *Parafusulina loeyensis* Pitakpaivan, and *Parafusulina* sp.A Dunbar and Skinner.

Khao Wat Kirinakratanaram : *Neofusulinella lantenoisi* Deprat, *Neofusulinella* cf. *saraburiensis* Toriyama, Kanmera, and Ingavat, *Pseudodoliolina pseudolepida* Deprat, *Sumatrina annae* Volz, *Verbeekina verbeeki* (Geinitz), *Parafusulina gigantea* (Deprat) and *Parafusulina loeyensis* Pitakpaivan.

The data of fusulinids (Table 4.1) shows that the fauna of Khao Wong is different from the other two hills, except *Verbeekina verbeeki*. Therefore, based on fusulinids assemblage and stratigraphy, biostratigraphy of study area is separated into two parts : biostratigraphy of Khao Wong and biostratigraphy of Khao Chakkachan (including Khao Wat Kirinakratanaram).

Locality	Khao	Khao		Khao Wong			
	Wat Kirinak ratanaram	Chakkachan					
Rock units	C <sub>1</sub>	C <sub>1</sub>	C <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	W <sub>3</sub>	W <sub>4</sub>
Fusulinids							
<i>Chusenella</i> cf. <i>schwagerinaeformis</i>					X		
<i>Colania douvillei</i>				@			
<i>Metadololina nongmuangensis</i>					@	o	
<i>Neofusulinella lantenoisi</i>	o	o					
<i>Neofusulinella</i> cf. <i>saraburiensis</i>	o	o					
<i>Parafusulina gigantea</i>	X	X	@				
<i>Parafusulina loeyensis</i>	X	X	@				
<i>Parafusulina</i> sp.A			X				
<i>Pseudodololina pseudolepida</i>	@	@					
<i>Pseudofusulina</i> sp.					X		
<i>Sumatrina annae</i>	@	@					
<i>Sumatrina</i> cf. <i>longissima</i>				@			
<i>Verbeekina verbeeki</i>	@	@			o	o	

@ = abundant

o = common

X = rare

Table 4.1 Distribution of fusulinids within the thesis area.

#### 4.1.1 Biostratigraphy of Khao Wong

Khao Wong sections are found along the northwest part of the Khao Wong where continuous exposures exclusively of limestones with N70W to N10E trend, dipping 13-45 to west and 10-15 to east are studied. They are subdivided into 4 rock units :  $W_1$ ,  $W_2$ ,  $W_3$ , and  $W_4$ . The upper unit  $W_4$  overlies the middle unit  $W_3$  and unit  $W_2$  with conformable bed of different lithology. The lower unit  $W_1$  is presumed to be in fault relation to the middle unit  $W_2$  and the actual contact has been confirmed in the field.

Fusulinids fossils occur so abundantly only in unit  $W_1$  and unit  $W_2$ , while unit  $W_3$  and unit  $W_4$  contain only very rare reworked or fragments of fusulinids. The range chart of fusulinids at Khao Wong in Table 4.2 shows that, the Tak Fa formation at northwest wing of Khao Wong is subdivided into the following three zones.

Upper	Fusulinid barren zone
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Middle	<i>Metadoliolina nongmuangensis</i> zone
	-----fault-----
Lower ?	<i>Colania douvillei</i> zone

#### *Colania douvillei* zone

This zone is characterized by *Colania douvillei* (Ozawa), it occurs together with *Sumatrina cf. longissima* (Deprat) throughout the zone. The zone is bounded along the interval between the lowest and highest occurrence of the confirmed species *Colania douvillei* (Ozawa). It exists in the rock unit  $W_1$ .



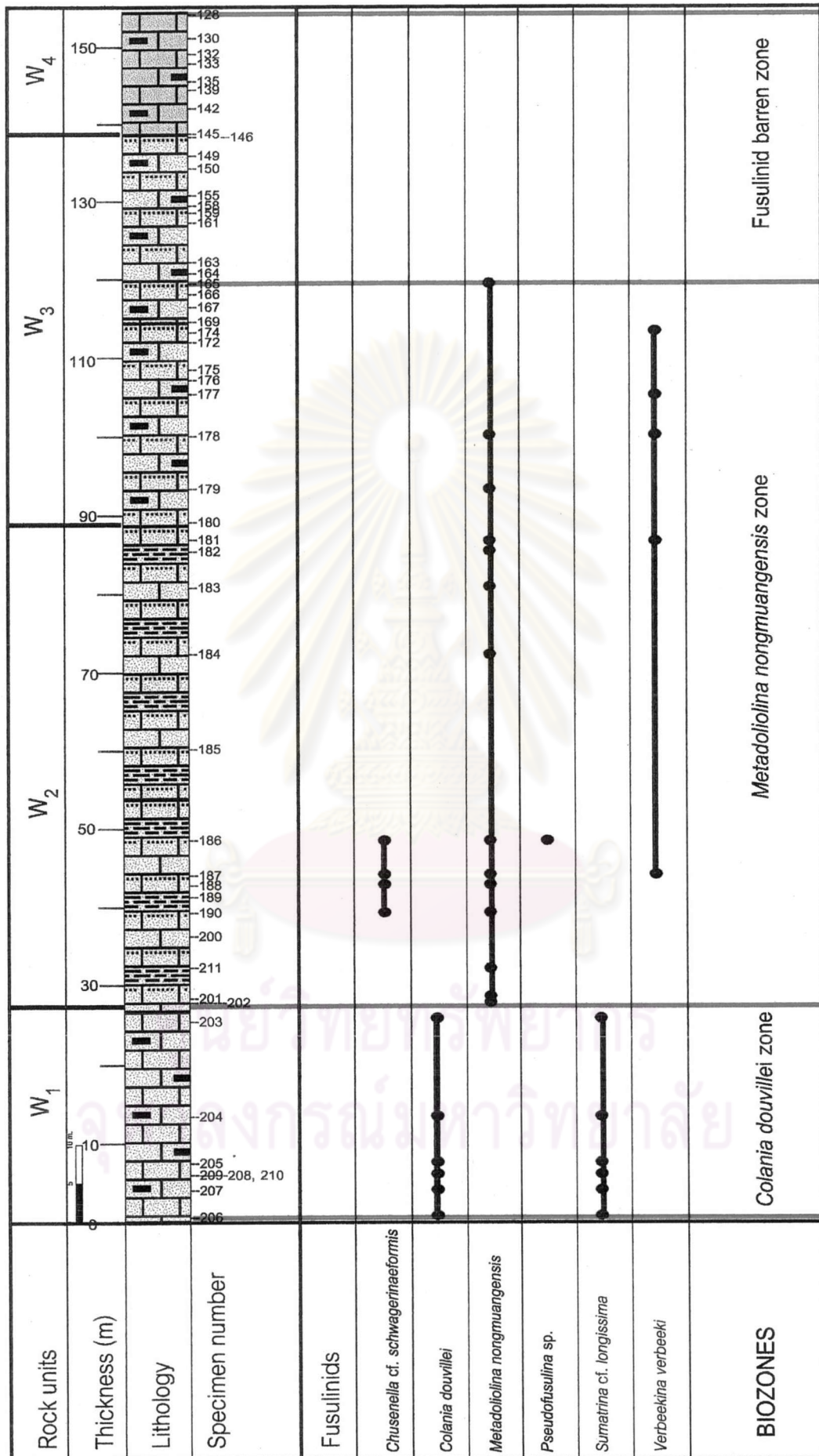


Table 4.2 Range chart of fusulinids at Khao Wong.

### ***Metadoliolina nongmuangensis* zone**

This zone is characterized by *Metadoliolina nongmuangensis* sp.nov., the zone species abundantly occurs in the middle and lower part of the zone. *Verbeekina verbeeki* (Geinitz) commonly appeared in some horizon of the middle part of the zone.

This zone exists throughout the rock unit  $W_2$  and the middle part of rock unit  $W_3$ , in horizon of specimens number TT0165 in which fusulinids *Metadoliolina nongmuangensis* sp. nov. last appeared.

*Chusenella* cf. *schwagerinaeformis* Sheng appeared at the lower part of the zone. *Pseudofusulina* sp. Dunbar and Skinner occurs in a bed of the lower part of this zone. Although this species and other species in the zone are stratigraphically not concurrent, the strata defined by these species are provisionally combined into one rock unit.

The zone is bounded along the interval between the lowest and highest occurrences of *Metadoliolina nongmuangensis* sp.nov.

### **Fusulinid barren zone**

This zone covered upper part of unit  $W_3$  and throughout unit  $W_4$ . Fossils are very very rare throughout the zone; they are smaller forams, brachiopods, massive rugose corals, solitary rugose corals, gastropods, crinoid stems, fusulinid fragments, and shell fragments. This zone is classified as fusulinid barren zone.

#### **4.1.2 Biostratigraphy of Khao Chakkachan (including Khao Wat Kirinakratanaram)**

Due to correlation of Khao Chakkachan and Khao Wat Kirinakratanaram that the single unit of Khao Wat Kirinakratanaram is equivalent to unit  $C_1$  of Khao Chakkachan in

bedding, lithology and fusulinids assemblage. Thus, the biozones of both areas can be grouped together. After range chart of fusulinids at Khao Chakkachan in Table 4.3, the limestones of Tak Fa formation at Khao Chakkachan including Khao Wat Kirinakratanaram are subdivided into 2 zones as follows.

Upper	<i>Parafusulina gigantea</i> - <i>Parafusulina loeyensis</i> zone
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Lower	<i>Pseudodoliolina pseudolepida</i> - <i>Neofusulinella lantenoisi</i> zone

***Pseudodoliolina pseudolepida* - *Neofusulinella lantenoisi* zone**

The zone consists of *Neofusulinella lantenoisi* Deprat, *Neofusulinella* cf. *saraburiensis* Toriyama, Kanmera and Ingavat, *Pseudodoliolina pseudolepida* (Deprat), *Sumatrina annae* Volz, *Verbeekina verbeeki* (Geinitz), *Parafusulina gigantea* (Deprat), and *Parafusulina loeyensis* Pitakpaivan.

*Neofusulinella lantenoisi* Deprat commonly occurs along with *Neofusulinella* cf. *saraburiensis* Toriyama, Kanmera and Ingavat throughout the zone.

*Pseudodoliolina pseudolepida* (Deprat) abundantly appears in the upper to the middle part of the zone abundant *Sumatrina annae* Volz, and *Verbeekina verbeeki* (Geinitz).

*Parafusulina gigantea* (Deprat) is commonly found in the upper part of the zone and rarely found in the lower part of the zone and ranges up into the superjacent zone. *Parafusulina loeyensis* Pitakpaivan is very rarely found in the upper part of the zone and extends to the superjacent zone.



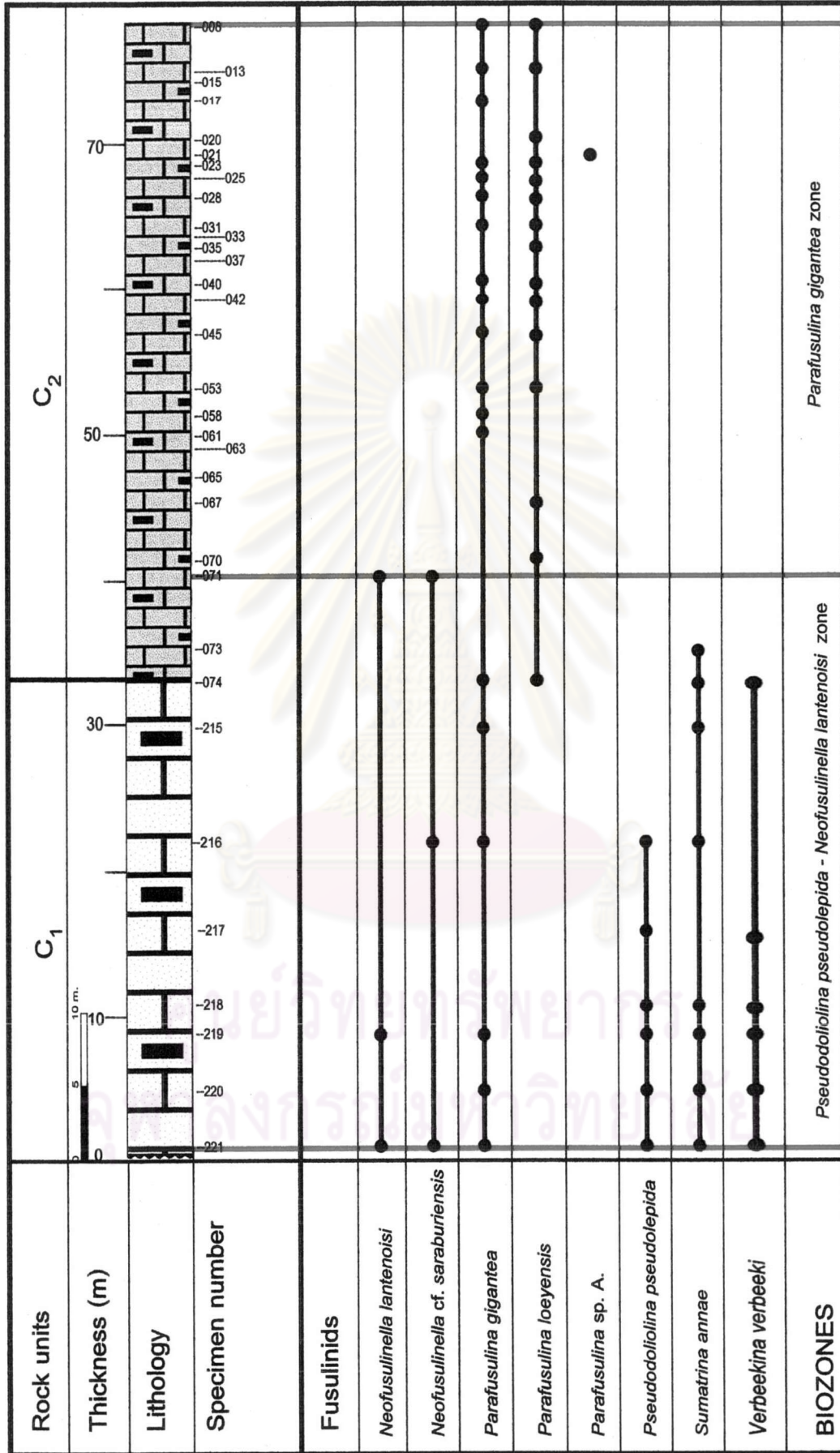


Table 4.3 Range Chart at Khao Chakkachan.

Among seven species of the zone, the three index species: *Neofusulinella lantenoisi* Deprat, *Pseudodoliolina pseudolepida* (Deprat), and *Sumatrina annae* Volz are common to very abundant. Thus, the lower boundary of this assemblage zone is lined when *Pseudodoliolina pseudolepida* (Deprat), and *Sumatrina annae* Volz appears. The upper boundary of this assemblage zone is bounded by the last appearance of *Neofusulinella lantenoisi* Deprat. This zone exists throughout the rock unit C<sub>1</sub> and the lower part of unit C<sub>2</sub>.

#### ***Parafusulina gigantea* – *Parafusulina loeyensis* zone**

This zone contains *Parafusulina gigantea* (Deprat), *Parafusulina loeyensis* Pitakpaivan, and *Parafusulina* sp. A Dunbar and Skinner.

*Parafusulina gigantea* (Deprat) occurs continuously from the subjacent zone, its occurrence abundant throughout unit C<sub>2</sub>.

*Parafusulina loeyensis* Pitakpaivan occurs abundantly throughout the zone. It is also very rarely found in the upper part of subjacent zone too. *Parafusulina* sp. A Dunbar and Skinner are very rarely found in the middle part of the zone.

The boundaries of this zone are lined after interval between successive documented disappearance of *Neofusulinella lantenoisi* Deprat and document of highest occurrence of *Parafusulina gigantea* (Deprat) and *Parafusulina loeyensis* Pitakpaivan.

#### **4.2 Age**

The fusulinids of study area belong to the types of fusulinids which are widely distributed in the Permian of East and Southeast Asia. The rocks in which the fusulinids have been found are believed to be contemporaneous and are ranging from Middle



Wordian to Middle Capitanian. Range of fusulinids recorded by many authors is shown in Table 4.4.

Period	Permian								
	Cisuralian				Guadalupian			Lopingian	
Series	Asselian	Sakmarian	Artinskian	Kungurian	Roadian	Wordian	Capitanian	Wuchiapingian	Changhsingian
Fusulinids	Stages								
<i>Chusenella cf. schwagerinaeformis</i>						■			
<i>Colania douvillei</i>							■		
<i>Metadolololina nongmuangensis</i>						■	■		
<i>Neofusulinella lantenoisi</i>						■			
<i>Neofusulinella cf. saraburiensis</i>				■	■	■			
<i>Parafusulina gigantea</i>						■	■		
<i>Parafusulina loeyensis</i>				■	■	■			
<i>Parafusulina sp.A</i>						■	■		
<i>Pseudodolololina pseudolepida</i>						■	■		
<i>Pseudofusulina sp.</i>	■	■	■	■	■	■	■		
<i>Sumatrina annae</i>						■	■		
<i>Sumatrina cf. longissima</i>							■	■	
<i>Verbeekina verbeeki</i>					■	■	■		

Table 4.4 Range of fusulinids recorded by many authors : Loeblich and Tappan, 1988; Ozawa, 1970a; Pitakpaivan, 1966; Sheng, 1963; Tittirananda, 1976; Toriyama et al., 1969 and 1974; stages adjusted to the ICS Permian Subcommittee (Yugan et al., 1997).

#### 4.2.1 Age of *Pseudodoliolina pseudolepida* - *Neofusulinella lantenoisi* zone

This zone in unit C<sub>1</sub> of Khao Chakkachan and Khao Wat Kirinakratanaram and lower part of unit C<sub>2</sub> of Khao Chakkachan. Fusulinids are *Neofusulinella lantenoisi* Deprat, *Neofusulinella* cf. *saraburiensis* Toriyama, Kanmera, and Ingavat, *Pseudodoliolina pseudolepida* Deprat, *Sumatrina annae* Volz, *Verbeekina verbeeki* (Geinitz), *Parafusulina loeyensis* Pitakpaivan, and *Parafusulina gigantea* (Deprat).

The genus *Neofusulinella* is very good stratigraphic indicator for Kungurian to Wordian (Toriyama et al., 1969, 1974), the stratigraphic range of *Neofusulinella* cf. *saraburiensis* Toriyama, Kanmera, and Ingavat, *Neofusulinella lantenoisi* Deprat must be discussed. Toriyama et al. (1974) reported that *Neofusulinella* cf. *saraburiensis* Toriyama, Kanmera, and Ingavat exist in B<sub>2</sub>-B<sub>4</sub> zones of Khao Phlong Prab where he assigned that it is range from Kungurian to Upper Roadian, while *Neofusulinella lantenoisi* Deprat exist in B<sub>5</sub>-B<sub>7</sub> zones, and assigned as Upper Roadian to Upper Wordian. However, *Neofusulinella lantenoisi* Deprat and *Neofusulinella* cf. *saraburiensis* Toriyama, Kanmera, and Ingavat in study area occur along with abundant *Pseudodoliolina pseudolepida* (Deprat) of Middle Wordian to Middle Capitanian age (Ozawa, 1970a), abundant *Sumatrina annae* Volz of Middle Wordian (or Lower Wordian in present) to Upper Capitanian age (Ozawa, 1970a), and *Verbeekina verbeeki* (Geinitz) of Lower Wordian (or Lower Roadian in present) to Upper Capitanian age (Ozawa, 1970a). The age is also confirmed to be Wordian by massive rugose corals *Ipciphyllum subelegans*, *Multimurinus kmerianus* and *Multimurinus frechi* in Unit C<sub>1</sub> at Khao Wat Kirinakratanaram, these corals indicate Murghabian or Wordian in age (Fontaine et al., 1994). So, the deposition of oldest rock of study area should be start in Middle Wordian. Thus, the age of *Neofusulinella lantenoisi* -*Pseudodoliolina pseudolepida* zone of the study area is considered to be Middle Wordian.



Remarkable that the work of Ozawa (1970a), which presents refined age of index species of the Verbeekinidae and the Neoschwagerinidae from U.S.A., Central Asia, South China, and Japan, did not mention the Roadian stage, he named subdivision of Permian after Permian Subdivision by Glenister and Furnishi (1961). At present, it is well accepted that the former Lower Wordian equivalent to the Roadian (Yagan et al. 1997).

#### 4.2.2 Age of *Parafusulina gigantea* – *Parafusulina loeyensis* zone

This zone exists in unit C<sub>2</sub> of Khao Chakkachan. Fusulinids are *Parafusulina gigantea* (Deprat), *Parafusulina loeyensis* Pitakpaivan, and *Parafusulina* sp.A.

*Parafusulina gigantea* (Deprat) is Wordian in age (Toriyama and Kanmera, 1979), appeared together with *Parafusulina loeyensis* Pitakpaivan of Kungurian to Wordian (Pitakpaivan, 1966 and Tittiranada, 1976). Besides, the *Parafusulina gigantea* – *Parafusulina loeyensis* zone is conformably underlain by *Neofusulinella lantenoisi* – *Pseudodoliolina pseudolepida* zone in stratigraphic position and there is not any evidence of Capitanian. So, the zone of *Parafusulina gigantea* – *Parafusulina loeyensis* in study area is probably younger than Middle Wordian to Upper Wordian.

#### 4.2.3 Age of *Colania douvillei* zone

The *Colania douvillei* zone cover throughout the unit W<sub>1</sub> at northwest wing of Khao Wong. Abundantly, *Colania douvillei* (Ozawa) occurs along with *Sumatrina* cf. *longissima* (Deprat) in this unit.

The age of *Colania douvillei* (Ozawa) is Lower to Middle Capitanian (Ozawa, 1970a), while *Sumatrina* cf. *longissima* (Deprat) is Lower to Upper Capitanian (Ozawa, 1970a), thus, the age of *Colania douvillei* zone of the study area is probably Lower to Middle Capitanian in age.



#### 4.2.4 Age of *Metadoliolina nongmuangensis* zone

This zone exists throughout unit  $W_2$  and middle part of unit  $W_3$  at northwest wing of Khao Wong. Besides, the *Metadoliolina nongmuangensis* sp.nov. occurs abundant in the zone, *Verbeekina verbeeki* (Geinitz) is commonly found, a little amount of *Chusenella* cf. *schwagerinaeformis* and *Pseudofusulina* sp. are also observed.

The genus *Metadoliolina* is assigned as Middle Wordian to Middle Wuchiapingian (Ozawa, 1970a). *Metadoliolina nongmuangensis* sp.nov. in the study area is found abundantly together with *Verbeekina verbeeki* which range from Lower Roadian to Upper Capitanian (Ozawa, 1970a), *Chusenella* cf. *schwagerinaeformis* of Wordian age (Sheng, 1963) and very rare *Pseudofusulina* sp. that range higher than hitherto reported (Loeblich and Tappan, 1988 assigned as Asselian to Kungurian). Therefore, the zone of *Metadoliolina nongmuangensis* is possibly Middle Wordian to Upper Wordian in age.

#### 4.2.5 Age of fusulinid barren zone

This zone is located at upper part of unit  $W_3$  and unit  $W_4$  at northwest wing of Khao Wong. Although, stratigraphically, this zone is conformably underlain by unit  $W_2$  of *Metadoliolina nongmuangensis* zone and it should be younger than Upper Wordian in age, but there is not any evidence of Capitanian fossils in this zone. Thus, the rock strata of fusulinid barren zone of Tak Fa formation in study area may be deposit at the Upper Wordian time.

#### 4.3 Depositional environment

According to the paleogeographic map of Early to Middle Permian of northeastern Thailand (Weichowsky and Young, 1985 and Chonglakmani and Fontaine, 1992), Khao Wong and Khao Chakkachan, Amphoe Nong Muang, Changwat Lop Buri were probably

parts of Khao Khwang platform which were covered by shallow water (Figure 4.1). Based on observation macroscopic and microscopic features of the sedimentary rocks together with recognition of fossils in the thesis area, it could be interpreted the depositional environment after Reeckmann and Friedman (1982) as follows.

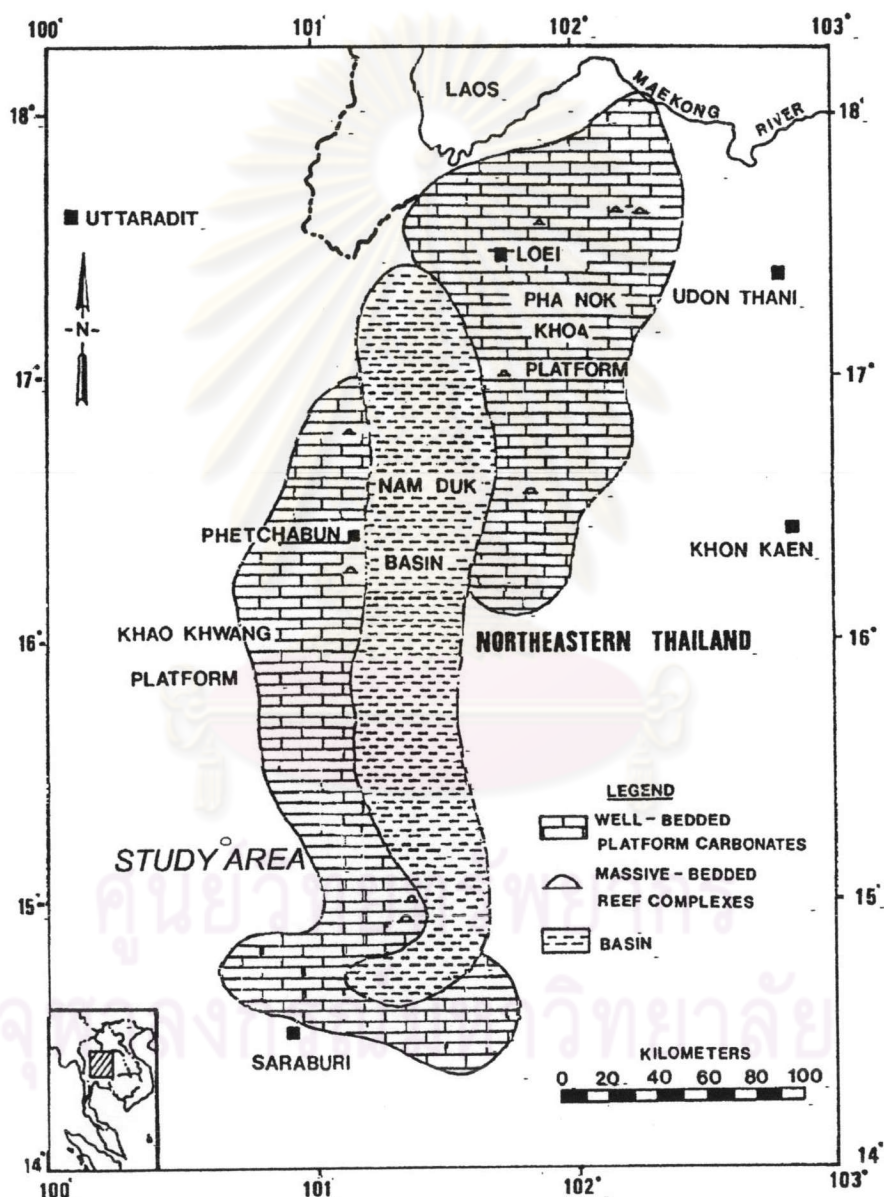


Figure 4.1 Paleogeographic map of Early to Middle Permian of northeastern Thailand (Chonglakmani and Fontaine, 1992).

Carbonate rocks of Khao Chakkachan unit C<sub>1</sub> are very thick – bedded, light gray to gray biosparite; biosparite indicates deposition in wave-agitated environment where micrite is removed by winnowing current and allowing mud-free carbonate to accumulate (Boggs, 1995). They are flourished with many species of fusulinids. Others faunas are common tabulate corals, brachiopods, bryozoans, solitary rugose corals, massive rugose corals, gastropods, rare fasciculate rugose corals, smaller forams, giant bivalves, algae, calcareous sponges and crinoid stems. It suggests that the unit C<sub>1</sub> possibly deposits in outer shelf of open marine in Middle Wordian time.

Unit C<sub>2</sub> of thick to very thick – bedded, gray to dark gray biomicritic limestones, and are flourished with fusulinids and approximately 30 cm-diameter of massive rugose corals. Others faunas are common brachiopods, bryozoans, solitary rugose corals, tabulate corals, gastropods, ostracodes, rare fasciculate rugose corals, smaller forams, algae, calcareous sponges and crinoid stems. It indicates that the unit deposits in low energy environment in of subtidal zone with open channel connect to open marine.

Unit W<sub>1</sub> of Khao Wong started in Lower Capitanian sea at outer shelf where very thick – bedded gray biomicrite flourished with fusulinids, algae, bryozoans, smaller forams and locally pellets deposit.

Unit W<sub>2</sub>, medium to thick- bedded, dark gray biomicritic limestone, with locally laminated dark gray shale interbedded contains abundant fusulinids and brachiopods indicate low-energy environment of subtidal zone. The limestone of unit W<sub>3</sub> and Unit W<sub>4</sub> of medium to thick - bedded, dark gray to gray fossiliferous micrite limestone. Fossils are very rare throughout the unit, mostly small fragments, locally large massive rugose. It possibly deposits in low- energy area, deeper water of outer shelf open marine in the Upper Wordian time.