CHAPTER I
INTRODUCTION

Fusulinids are extraordinarily profuse in many rock formations in Thailand and other countries. They are an exclusively late Paleozoic group of fossils and had the beginning in late Mississippian Period and extinct at the close of Permian Period. Fusulinids have been studied for more than 150 years by many paleontologists in many countries, because of their widespread geographic distribution around the world. Within the relatively short range of their collective existence, they developed into many phylogenetic lineages and rapid evolution. For these reasons they are one of the best index fossils. Its study gives good result and complete detail for biostratigraphy.

The rocks in the area of Khao Wong and Khao Chakkachan, Amphoe Nong Muang, Changwat Lop Buri were grouped as Permian limestone in the Tak Fa formation of the Saraburi Group. The fusulinid assemblages in this area are abundant but still need more investigation in detail. Thus, the area of Khao Wong and Khao Chakkachan, Amphoe Nong Muang, Changwat Lop Buri are suitable to study biostratigraphy with reference to fusulinids. A valuable experience on biostratigraphy of this study may be useful in future work on studying the Permian stratigraphy of Thailand for the author.

1.1 The study area

1.1.1 Location

The study area is situated at Khao Wong and Khao Chakkachan, Amphoe Nong Muang, Changwat Lop Buri (Figure 1.1). It covers approximately 30 square kilometers and lies between the latitude $15^{\circ}\ 10'\ 19''$ to $15^{\circ}13'\ 03''$ and longitude $100^{\circ}\ 38'\ 20''$ to $100^{\circ}\ 41'\ 40''$. The investigated area is located within the topographic map scale 1 : 50,000 of the Royal Thai Survey Department, sheet 5139 III, series L7017, edition 2-RTSD, Amphoe Ban Mi (Figure 1.2).

1.1.2 Accessibility

Accessibility to the study area can be undertaken via convenient route no.1 or Phahon Yothin Highway (Figure 1.3). By following the route no.1 to Ban Chon Saradet at km 203+100 m, then turn right and follows the concrete road for approximately 400 meters to Khao Chakkachan. Khao Wat Kirinakratanaram is located at left-hand size of km 203+600m. Going straight along route no.1 until meet the Nong Muang – Ban Mi Junction, turn left and follows the route no. 3354 for 1.7 kilometers, turn left again and moves along narrow loose- surface road approximately 800 meters to northwest wing Khao Wong, in the area of Amphoe Nong Muang, Changwat Lop Buri.

1.1.3 Physiography and Climate

The study area is located on the northern part of Changwat Lop Buri. The topography of the study area is characterized by the rolling terrain and limestone hills. The average elevation of the study area lies between 80- 300 meters above mean sea level. There is only a small stream "Klong Chon Khut" passing through the southeastern part of the study area.

The climate of the study area is tropical grassland or savanna type with the rainy season ranges from May to October while the rest of the year is relatively dry. The average annual rainfall is 1,137.16 millimeters in 101.6 rainy days (from the year 1969 to 1998). The average annual mean temperature is 28.34 degree celsius (from the year 1984 to 1998).

1.2 Purposes of study

Two main purposes of study can be classified as follows :

1. To identify the species of fusulinids in the study area.

2. To study biostratigraphy and determine age of rock in the study area by using fusulinids.

1.3 Medthodology

Generally, the methodology under the investigation can be categorized into three main aspects : office work, field work and laboratory work. The summarized flow chart of methods of study is illustrated in figure 1.4.

1.3.1 Office work

The office work includes the review on previous works of other geologists/ paleontologists conducted at and/or near the investigation area. Topographic map, geologic map, and aerial photographs of the study area were studied.

1.3.2 Field work

The field investigation has been carried out into 2 steps : the reconnaissance field investigation and detailed field investigation. Initial reconnaissance field investigation was taken place for understanding generally of the study area. Detailed field investigation had been carried out from March, 1999 to May, 2000 for measuring of seven sections of totally 269.60 meters including the sampling of 200 rock samples from the measures rock sections.

1.3.3 Laboratory work

In laboratory, 600 thin-sections of rocks have been prepared for petrographic and paleontologic identifications. Petrography of rocks were studied through polarizing microscope. The terminology used here to describe the limestone is based mainly on Folk's classification (1959 and 1962 in Boggs, 1995). Detailed study of morphology and size measurement of fusulinids have been acted through stereo-zoom microscope and biological microscope.

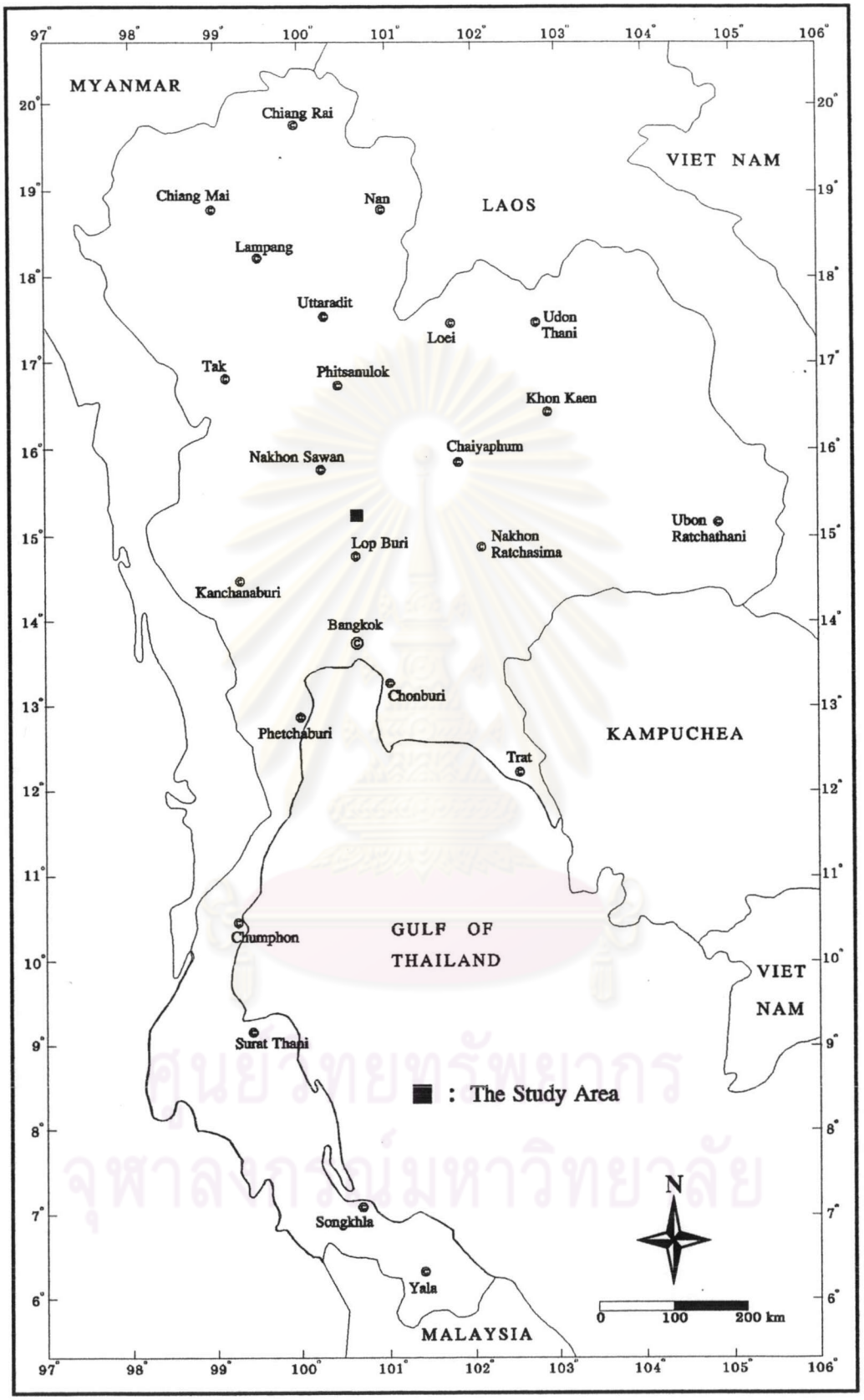

Figure 1.1 Index map of Thailand showing location of the study area in Changwat Lop Buri.

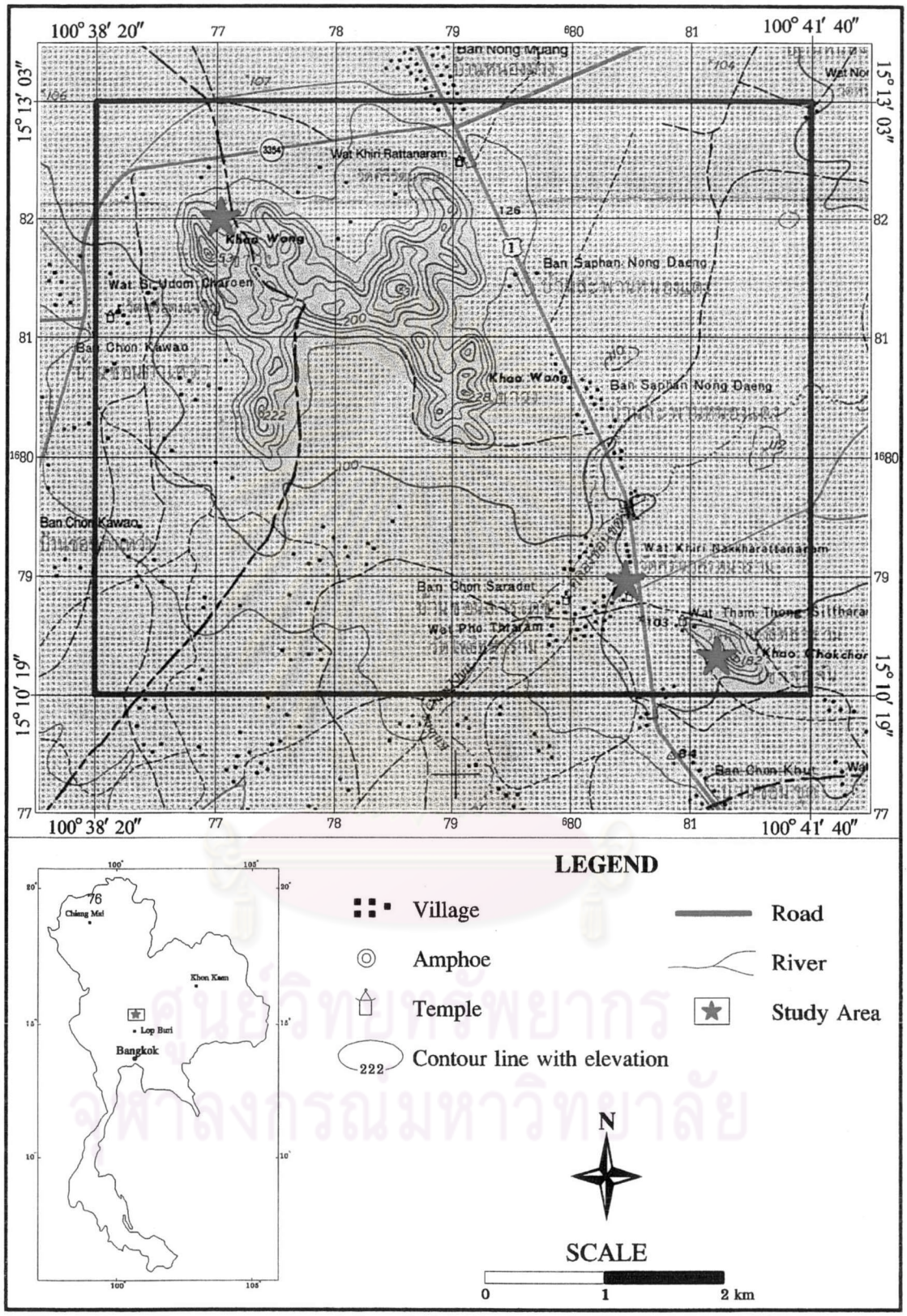

Figure 1.2 Topographic map of the study area, scale 1 : 50,000, sheet 5139 III, Amphoe Ban Mi, series L 7017, edition 2-RTSD.

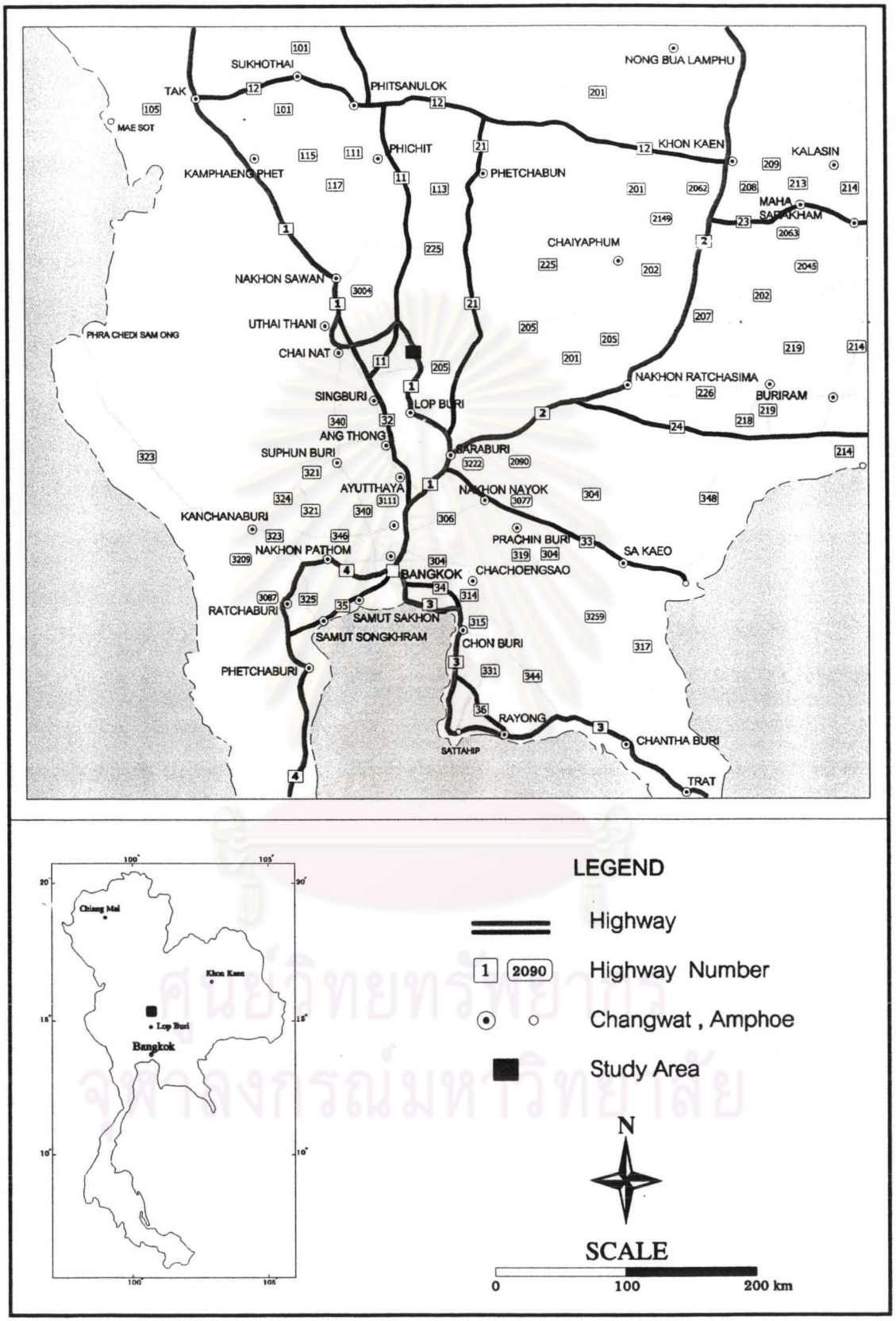

Figure1.3 A route map showing the accessibility to the study area.

The data from field work and laboratory provide the range chart of fusulinids and establish the biozones of the study area. The biostratigraphic classification in this thesis is based on the international stratigraphic guide of International Subcommission on Stratigraphic of IUGS Commission on Stratigraphy (Hedberg, 1976).

1.4 Previous investigation

According to Geological Survey Report Number 3 on Geology and Mineral Resources of Amphoe Ban Mi (Nakornsri, 1981) and a geologic map scale 1 : 250,000, map sheet Amphoe Ban Mi (Nakornsri, 1977) reported that the investigated area is a part of Tak Fa formation. The Tak Fa formation is lower Middle Permian (Artinskian-Kungurian) in age and is a part of Saraburi Group (formerly Rat Buri Group). The detail of geology in that study will be reported in the Chapter II.

The study of fusulinids in Thailand started at 1939, Dunbar reported the occurrence of middle Permian fusulinids (*Neoschwagerinids* and *Schwagerinids*) in limestone collected by Heim and Hirschi from Ban Dara Junction, south of Changwat Uttaradit, central-north Thailand. After that, fusulinids have been most focussed on by many researchers.

Fusulinids from northern Thailand have been studied by many paleontologists : Dunbar (in Heim and Hirschi, 1939), Toriyama (1944), Konishi (1953), Kemper (1969 in Toriyama, 1984), Pitakpaivan et al. (1969), Baum (1970), Hahn and Siebenhuner (1982), Sakagami and Hatta (1982), Ingavat (1984), Ingavat and Jumnongthai (1988), Caridroit et al.(1990), Ueno and Sagakami (1991), Vachard et al.(1992), Ishibashi et al.(1994), and Ueno and Igo (1997).

Those from central Thailand have been more widely studied and known by many researchers : Toriyama and Sugi (1959), Borax and Stewart (1966), Pitakpaivan (1966), Toriyama and Kanmera (1968), Toriyama et al. (1969), Ozawa (1970b), Toriyama and

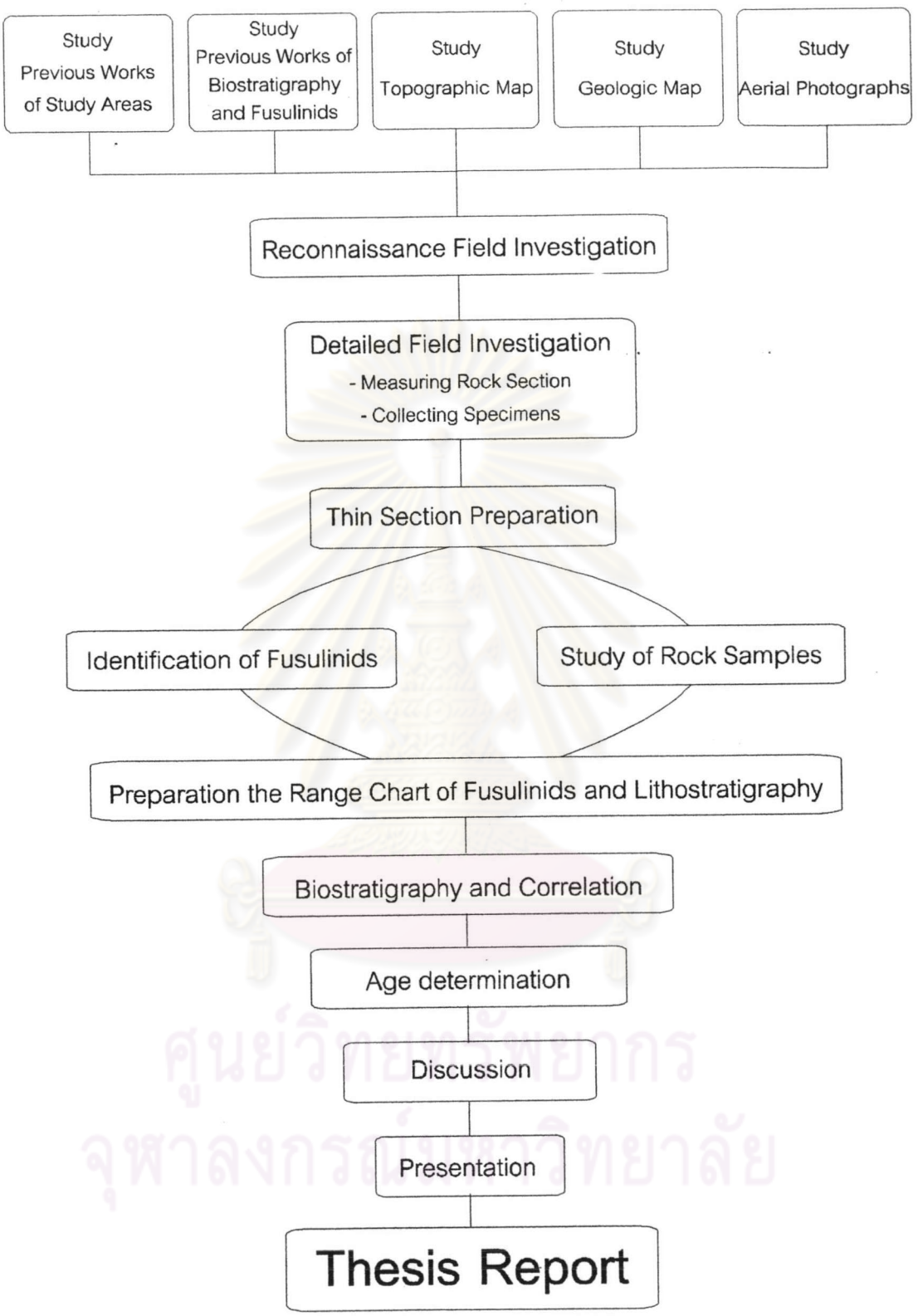

Figure 1.4 The summarized flow chart of methodology.

Pitakpaivan (1973), Toriyama et al. (1974, 1975), Tittirananda (1976), Toriyama (1976), Toriyama and Kanmera (1977), Toriyama (1978), Toriyama and Kanmera (1979), Wielchowsky and Young (1985), Altermann (1989), and Dawson and Racey (1993).

Whereas in northeastern Thailand, the fusulinids were studied by Borax and Stewart (1966), Pitakpaivan (1966), Igo (1972), Sakagami and Iwai (1974), Toriyama (1982), Wielchowsky and Young (1985), Vachard (1990), Fontaine et al. (1991), Igo et al. (1993), Ueno and Igo (1993), Ueno and Sakagami (1993), Charoentitirat (1995), and Charoentitirat and Ueno (1999).

The studies in eastern Thailand include Nakinbodee et al. (1976), Pitakpaivan and Ingavat (1980), Sugiyama and Toriyama (1981), Bunopas et al. (1983), Fontaine et al. (1997), and Fontaine and Salyaponse (1997).

Fusulinids in the west and southern peninsular had been studied since 1939 by Dunbar (in Heim and Hirschi, 1939) at Pawa, Changwat Tak, but more extensively studied during the three last decade include Sakagami (1969), Baum et al. (1970), Hagen and Kemper (1976), Bronimann et al. (1978), Ingavat and Douglass (1981), Ingavat et al. (1975), Bunopas (1982), Hahn and Siebenhuner (1982), Fontaine and Suteethorn (1988), Vachard et al. (1992), Fontaine et al. (1993), and Ingavat-Helmcke (1993).

The detailed study of fusulinids especially in the vicinity of Lop Buri have been reported by many researchers. Pitakpaivan (1966) described *Schwagerina crassa padengensis* (Lange), *Schwagerina* cf. *tchengkiangensis* (Deprat) and *Schwagerina* sp.A from Khao Sanamjang. He concluded that the limestone at Khao Sanamjang is Artinskian to Upper Sakmarian-Artinskian in age. The stratigraphical succession and characteristic fusuline genera of the Rat Buri limestone include Khao Sanamjang limestone as shown in Table 1.1.

Toriyama and Pitakpaivan (1973) studied Middle Permian fusulines from Wat Kirinakratanaram Hill, Tambon Chonsaradet, Amphoe Nong Muang (formerly Amphoe Kok Samrong), Changwat Lop Buri. The samples were collected from five collection localities as shown in figure 1.5, of which the limestone at point 5 is barren of fusulinids. The fusulinids are *Nankinella*(?) sp., *Neofusulinella saraburiensis*, *Neofusulinella lantenoisi*, *Parafusulina gigantea*, *Verbeekina verbeeki*, *Pseudodoliolina pseudolepida*, and *Sumatrina annae* (Figure 1.7). These faunas are considered to be lower Middle Permian in age.

Wielchowsky and Young (1985) presented regional facies variations in Permian rocks of the Phetchabun Fold and Thrust Belt. They also studied fusulinids in many localities, included fusulinids at Khao Somphot an area of Tak Fa formation had been studied (Table 1.2).

The fusulinid zonations in Thailand have been established by many researchers. Igo (1972) established the standard columnar section showing stratigraphic position and range of fusulinaceans from the Wang Saphung-Loei areas and Petchabun-Lom Sak areas. This columnar section range from Middle Carboniferous to lower Lower Permian.

The biostratigraphic zonation of the Rat Buri limestone (Saraburi Group at present) in the Khao Phlong Prab area, Changwat Saraburi has been established by Toriyama et al. (1974). They expected that this section could be designated as the standard biostratigraphic sequence in the upper Lower to middle Middle Permian strata in Thailand. Next, Toriyama et al. (1975) also correlated biostratigraphic zonation of fusulinids in Thailand with Southeast Pamir, Shan State-Burma, Malaysia, Cambodia, South China, and Japan.

Toriyama and Kanmera (1979) studied middle Middle Permian fusulines from the Ratburi limestone (Saraburi Group at present) in the Khao Khao area, Changwat Saraburi. They also correlated the Khao Khao and Khao Phlong Prab sections with the

selected sequence in the eastern part of Tethys :Pamir, Afghanistan, Cambodia, South China, Akiyoshi southwest Japan, and Akasaka-central Japan.

Ingavat et al. (1980) presented fusuline zonation and faunal characteristics of the Rat Buri limestone (Saraburi Group at present) in Thailand and its equivalents in Malaysia and correlated with Transcaucasia, Iran, Southeast Pamir, Afghanistan, Pakistan, Malaysia, Indochina, South China, Southwest Japan, and other previous research in Thailand (Table 1.3).

Toriyama (1984) summarized the fusuline faunas in Thailand and Malaysia. He also correlated biostratigraphic zonation of fusulinids in Thailand with Mediterranian-Alpine Folded Belt, Darvaz, Southeast Pamir, Malaysia, and South China (Table 1.4).

Dawson (1991 in Dawson and Racey, 1993) established fusuline assemblage zones from Saraburi limestone which she designated that these zones range from Sakmarian to ?Lower Midian or ?Lower Capitanian (Table 1.5).

1.5 The Permian chronostratigraphic subdivisions

The selected fossil zones in chronostratigraphic scheme for the Permian System (Table 1.6) must be applied for determining the zones of study area. Names and boundary levels for series and stages of the Permian System, based on marine successions, have been approved by the Permian Subcommission, ICS. These are the Cisuralian, Guadalupian, and Lopingian Series and their constituent stages standardized respectively in the Urals, Southwest USA, and South China for the Lower, Middle, and Upper Permian (Yugan et al., 1997). For convenience of the readers, the author would like to show the correlation of selected Permain successions which are adopted from many authors' contributions as shown in Table 1.7.

Age	Stratigraphical succession	Characteristic fusuline genera
Kazanian (Wordian)	The limestone of Maoteetang	*Neoschwagerina*
	The limestone of Prongprab hill	
Kungurian	The calcareous shale of Huey Sampod	*Parafusulina*
Artinskian	The limestone of Chondhurian The limestone of Kao Sanamjang	*Sphaerulina* and *Neofusulinella* *Schwagerina*
Sakmarian	The limestone of Noankowtok	*Pseudoschwagerina*

Table 1.1 The stratigraphical succession and characteristic fusuline genera of the Rat Buri limestone (Pitakpaivan, 1966).

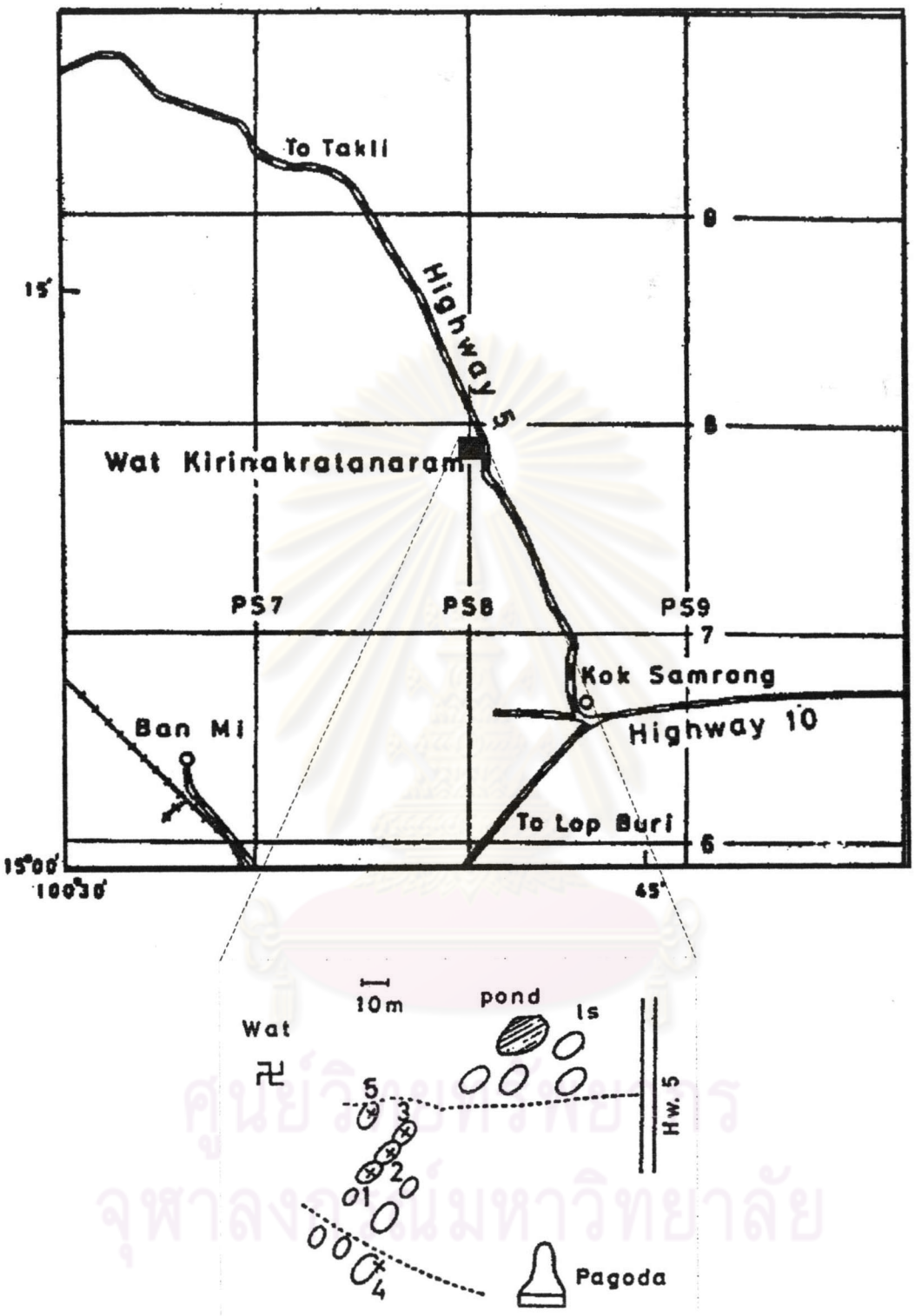

Figure 1.5 Localities of specimens collecting at Wat Kirinakratnaram (Toriyama and Pitakpaivan, 1973).

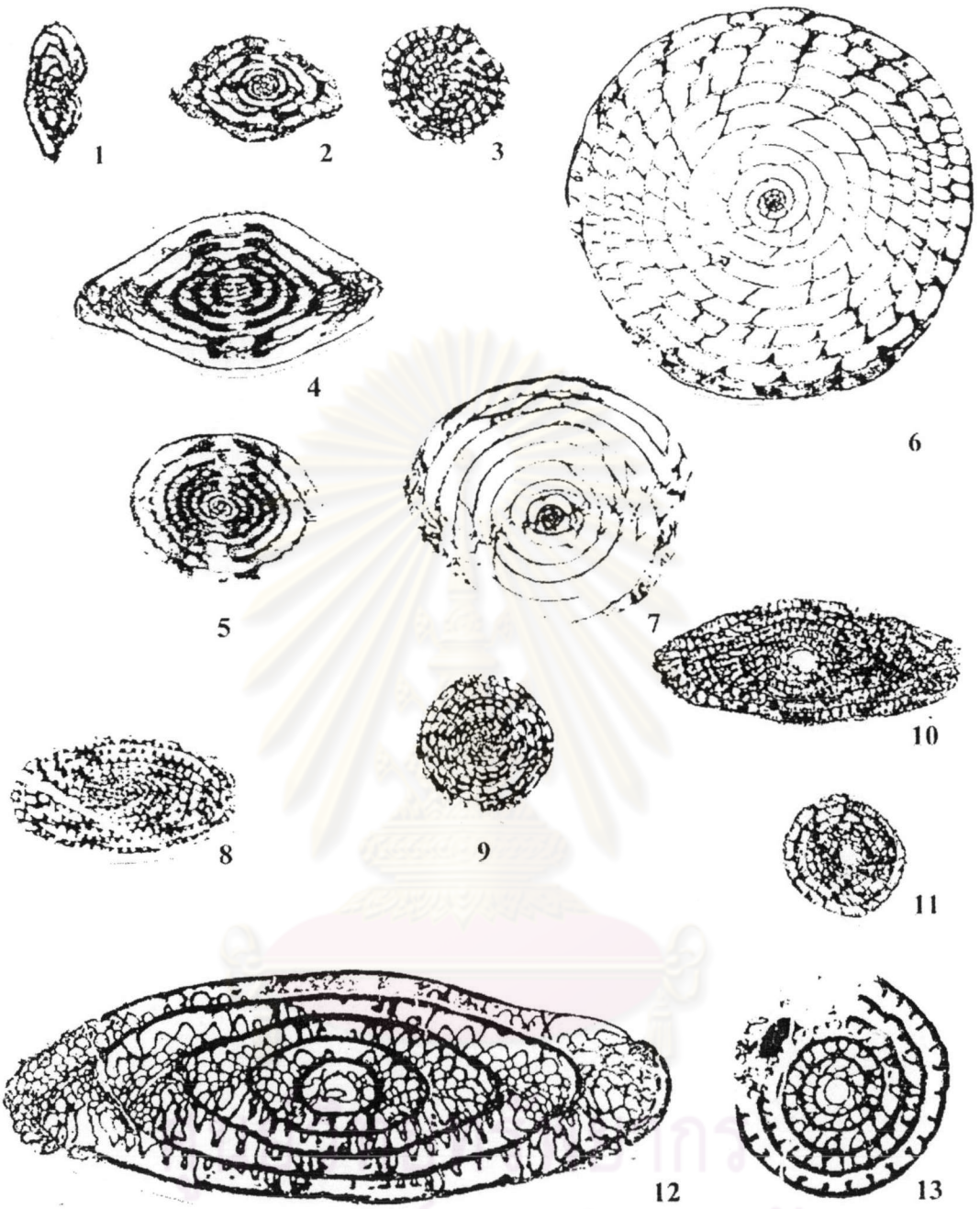

Figure 1.6 The fusulinids from Wat Kirinakratanaram (Toriyama and Pitakpaivan,1973) :

1. *Nankinella* (?) sp., x20; **2-3.** *Neofusulinella saraburiensis* Toriyama, Kanmera, Ingavat, x20; **4-5.** *Neofusulinella lantenoisi* Deprat, x20; **6-7.** *Verbeekina verbeeki* (Geinitz), x10; **8-9.** *Pseudodoliolina pseudolepida* (Deprat), x10; **10-11.** *Sumatrina annae* Volz, x10; **12-13.** *Parafusulina gigantea* (Deprat), x10.

Location	Facies	Fusulinids	Age
Khao Somphot (15°06′-07.5′N, 101°18′-19′E)	Skeletal grainstones and packstones located in platform interior	*Lepidolina multiseptata* (Deprat), *Verbeekina verbeeki* (Geinitz)	Late Guadalupian
Khao Somphot (15°06′-07.5′N, 101°18′-19′E)	Skeletal grainstones located in platform interior	*Metadoliolina* cf. *gravitesta* (Kanmera), *Verbeekina douvillei*, *Kahlerina* sp., *Boutonia* sp., *Nankinella* sp.	Late Guadalupian
Phu Pha Daeng (16°51.5′N, 101°56.5′E)	Thin-and thick-bedded limestones, shales, sandstones and matrix-supported conglomerates	*Parafusulina* cf. *kaerizensis*, *Schwagerina* cf. *pindingensis* Sheng, *Pseudodoliolina* cf. *pseudolepida* (Deprat) *Neoschwagerina* cf. *akasakensis* Morikawa and Suzuki	Middle Guadalupian
NW of Saraburi (14°40.5′N, 100°50.5′E)	Thin-to massive-bedded limestone conglomerates, thick- to thin-bedded limestones and shales	*Neofusulinella* cf. *lantenoisi* Deprat, *Presumatrina* sp., *Thailandina* sp., Schwagerinid	Middle Guadalupian
Khao Wong (15°03′N, 101°22′E)	Massive coral-algae-sponge boundstones and dolomites located at basinward edge of platform	*Parafusulina* ex. gr. *gruperoensis-uenoensis*, *Pseudodoliolina* sp.	Early Guadalupian
Khao Somphot (15°06′-07.5′N, 101°18′-19′E)	Carbonate mudstones and skeletal wackestones in platform interior	*Parafusulina* sp. (primitive) *Cancellina* cf. *tenuitesta* Kanmera, *Yanchienia* cf. *haydeni* Thompson, *Presumatreina schellwieni* (Deprat)	Early Guadalupian
Phu Pha Daeng (16°51.5′N, 101°56.5′E)	Carbonate mudstones and skeletal wackestones, fusulinids grainstones	*Parafusulina* cf. *yabei*, *Parafusulina japonica*, *Parafusulina* cf. *gruperaensis* Thompson and Miller, *Yanchenia* cf. *compressa*, *Gallowayinella* (?) sp., *Schubertella* sp., *Misellina termieri* (Deprat), *Misellina confragaspira* Leven, ?*Acervoschwagerina*? sp.	Artinskian
South of Pha Nok Khao (16°43′N, 102°00′E)	Fusulinids carbonate mudstones located in platform interior	*Schwagerina* cf. *tschernyschewi* (Schellwien), *Pseudofusulina* cf. *valida* (Lee), *Pseudofusulina* sp., *Staffella ?* sp.	Sakmarian
Khao Somphot (15°06′-07.5′N, 101°18′-19′E)	Thin-and thick-bedded limestones and shales	*Pseudoschwagerina moelleri* (Rauser), *Dukevichia devexa* Rauser, *Quasifusulina cayeusi* (Deprat), *Pseudofusulina* sp.	Asselian
Khao Somphot (15°06′-07.5′N, 101°18′-19′E)	Carbonate mudstones and skeletal wackestones located in platform interior	*Schubertella kingi* Dunbar and Skinner, *Paraschwagerina vlasovi* Leven, *Pseudofusulina* (P.) *bornemani* Leven, *Pseudofusulina* (P.) *explicata* Leven	Asselian

Table 1.2 Selected representative fusulinid faunas in Permian rock of the Phetchabun fold and thrust belt. (Wielchowsky and Young, 1985).

10^6y	System	Series	Fusuline Genus Zone	Transcaucasia (Ruzhencev & Sarycheva, 1965; Leven, 1975)	Iran(Abadeh) (Taraz, 1971-74)	Southeast Pamir (Miklukho Maklai, 1963; Leven, 1967)	Afghanistan (Siehl, 1967; Lys & Lapparent, 1971; Leven, 1971; Lys, 1977)	Pakistan (Nakazawa et al., 1975)	Thailand (Pitakpaivan, 1963; Baum et al., 1970; Igo, 1972; Toriyama et al., 1974; 1978, Pitakpaivan & ingavat, 1978)	Malaysia (Igo, 1964; Ishii, 1966; Ozawa, 1976; Aw et al., 1977)	Indochina (Cambodia) (Saurin, 1967; Ishii et al., 1969)	South China (Sheng, 1963)	Southwest Japan (Ota et al., 1973; Nakazawa et al., 1973)
247	TRIASSIC	Lower		Claraia Beds	Ophiceras	Tı		Mianwali Fm.	Lampang Group	Claraia		Yehlang / Tsych / Ching lung	Kamura Fm.
	PERMIAN	Upper	Dorashamian	Dorash. Paratirolites; Shevyrevites Phisonites	Induan 7 Paratirolites; Shevyrevites	Karab. F. Palaeofusulina pamirica; Reichelina pulchra; Colaniella parva	Colaniella parva; Codonofusiella	"Basal Kathwai"	Palaeofusulina sinensis	Gua Musang Fm. Palaeofusulina af. Bella-Colaniella parva		Changhsing Palaeofusulina sinensis; Colaniella parva	Mitarai Palaeofusulina af.sinensis; Colaniella parva
			Dzhulfian	Dzhulf. Vedioceras; Araxoceras; Araxilevis	6 Vescotoceras; Araxoceras			Chhidru				Wuchiaping Codonofusiella; Colaniella minima	Kumura Palaeofusulina simplex; Colaniella minima
253			Abadehian	Khachik Codonofusiella; Reichelina; Chusenella	Abadeh. 5 Codonofusiella Reichelina; 4 Staffella	Gamsk F.	Kalabagh	Colaniella minima	Lepidolina multiseptata		D IV Lepidolina multiseptata		Lepidolina kumaensis
			Lepidolina-Yabeina	Arpin Chusenella abichi; Sumatrina	3 Chusenella abichi; 2 Chusenella sp.A		Watyal F. Codonofusiella; Reichelina				C III Sumatrina annae longissima-Lepidolina multiseptata		Lepidolina multiseptata
259		Middle	Guadal-pian Pamirian	Yabeina	Guadalupian	Yabeina archaica	?		Colania douvillei; Verbeekina verbeeki	Yabeina asiatica	B II Sumatrina annae longissima-Yabeina asiatica	Maokou	Lepidolina multiseptata shiraiwensis; Colania douvillei
			Murgabian	Gnishik Eopolydiexodina; Verbeekina; Pseudodoliolina	Neoschwagerina margaritae; Neoschwagerina af.craticulifera Parafusulina	Gamsk F. Neoschwagerina margaritae; Neoschwagerina schuberti; Sumatrina, Verbeekina; Neoschwagerina simplex; Presumatrina	Neoschwagerina margaritae; Neoschwagerina schuberti; Neoschwagerina simplex; Polydiexodina afghanensis				A I Pseudodolipolina pseudolepida-Pseudofus. ambigua pursatensis		Neoschwagerina margaritae
			Kubergandian	Neoschwagerinoid; Cancellina; Parafusulina	Eopolydiexodina	Kubergandian F. Cancellina, Armenia; Parafusulina; Misellina; Pseudodoliolina; Pseudofusulina vulgaris formis	Parafusulina tumida; Parafusulina multiseptata; Rugosofusulina complicata lancetiformis; Monodiexodina fergana; Parafusulina af. japanica	Amb. F. Glossopteris; Gangamopteris; Monodiexodina	Neoschwagerina craticulifera; Neoschwagerina simplex	Neoschwagerina craticulifera; Neoschwagerina simplex		Neoschwagerina craticulifera	Neoschwagerina craticulifera
269			Para-fusulina Cancellina	Asnyg.					Maklaya sethaputi; Maklaya pamirica; Maklaya saraburiensis; Misellina confragaspira; Misellina otai; Misellina cft. termieri			Cancellina	Akasakan Cancellina nipponica; Afghanella schencki; Parafusulina Kaerimizensis
278		Lower	Artinskian Misellina	Misellina		Vazaridarin F. Monodiexodina shiptoni	Rugosofusulina ex.gr vulgaris formis; Pseudofusulina composita; Oncholites & Algae	Saradhoi F.		Misellina claudiae; Pseudofusulina krafft	Calcaire	Chihsia Misellina	Nakoyaman Misellina claudiae; Pseudofusulina ambigua
			Sakmarian Pseudo-fusulina	Dabaly. Pseudofusulina	Schwagerina Pseudo-schwagerina			Warchha F.			a'	Maping Pseudoschwagerina	Sakamotozawan Pseudofusulina vulgaris
			Asselian Pseudoschwagerina					Dandot F.	Triticites ozawai-Pseudoschwagerina yanagidai				Triticites simplex
289		Upper	Orenburgian			(Northern Pamir) (Lys, 1977) ? Quasifusulina longissima; Triticites sp.	Pseudoschwagerina melleri	Tobra F.					(Missing)
			Gzhelian Triticites								?		Hikawan Triticites matsumotoi
306			Kassimovian						Protriticites tethydis				
		Middle	Moscovian Fusulina-Fusulinella			Fusulina mosquensis; Fusulinella colaniae	Fusulinella praecolianae; Profusulinella pseudolibrovichi		Fusulina pulchella; Hemifusulina(?) Thaiensis; Beedeina paradistenta; Profusulinella ptisca timanica; Profusulinella parva		Fusulines	Fusulinella	Kamura Beedeina akiyoshiensis; Akiyoshian Fusulinella bicornica
			Profusulinella			Profusulinella prisca; Neostaffella ozawai; Eostaffella pseudostruvei	Endothyranopsis crassus; Pseudostaffella; Eostaffella pseudostruvei				(North Vietnam) (Saurin, 1967)	Huanglung Profusulinella	Akiyoshian Akiyoshiella ozawai; Profusulinella beppensis; Kanokian Pseudostaffella antiqua
330			Bashkirian								Eostaffella pseudostruvei; Eostaffella parastruvei		
			Millerella-Eostaffella				Eostaffella varvariensis; Eostaffella parastruvei			Eostaffella mosquensis			(Missing)
341		Lower	Namurian										Onumaian Millerella yowarensis
			Visean							Millerella tossica	Mediocris mediocris		Nagatophyllum satoi
355			Tournaisian										Zaphrentoides sp.
													Marginatia toriyamai
367													

Table 1.3 Correlation of biostratigraphic zonation of fusulinids in Thailand with Transcaucasia, Iran, Southeast Pamir, Afghanistan, Pakistan, Malaysia, Indochina, South China, Southwest Japan, and other previous researchs in Thailand (Ingavat et al., 1980).

Permian-Tethys Stage Scale in the Mediterranean-Alpine Folded Belt (ISC, USSR, 1979), (Leven, 1981)			Darvaz (Leven and Scherbovich, 1978)		S.E. Pamir (Leven, 1967, 1980)		Thailand (Pitakpaivan, 1963; Baum et al., 1970; Igo, 1972; Toriyama et al., 1975, 1978; Ingavat et al., 1978; Pitakpaivan & Ingavat, 1978)		Malaysia (Igo, 1964; Ishii, 1966; Ozawa, 1976; Aw et al., 1977; Igo et al., 1978)		South China (Xiang et al., 1980; Rui, 1981; Zhao et al., 1981)	
Series	Stage	Zone										
PERMIAN Yaikian	Dorashamian	*Paratirolites kittli* *Shevyrevites shevyrevi* *Dzhulfites spinosus* *Iranites transcaucasium* *Phisonites triangulus*			Tachtabulak	*Palaeofusulina* ex.gr. *fusiformis* *Paradunbarula pamirica* *Codonofusiella, Reichelina*	MIDDLE PERMIAN Upper	?	*Palaeofusulina sinensis* *Colaniella parva*	Khao Doi Pha Phlung	*Paleofusulina* aff. *bella* - *Colaniella parva*	Sungei Lebir	*Palaeofusulina sinensis* *Reichelina changhsingensis*
	Dzhulfian	*Vedioceras ventroplanum*										*Gallowainella meitienensis* *Palaeofusulina minima*
		Araxoceras latum		*Tschernyschewia typica*	Gan Kastanatdjilga	*Colaniella parva* *Yabeina* ex.gr. *opima* *Chusenella ishanensis*		*Lepidolina multiseptata multiseptata*	Srakeow			*Codonofusiella kwangsiensis*
	Midian	*Yabeina - Lepidolina*	Kafirbatcha Kaftarmol	*Gondolella bitteri* *Stepanovites inflatus*		*Neoschwagerina margaritae* *Yabeina archaica*		*Colania douvillei* - *Verbeekina verbeeki*	Khao Imol	*Yabeina asiatica* - *Sumatrina annae*	Jengka Pass	*Neomisellina* - *Codonofusiella* *Yabeina* - *Neomisellina*
	Murgabian	*Neoschwagerina margaritae* *Neoschwagerina craticurifera* *Neoschwagerina simplex*	Daraitang Valvaljak			*Neoschwagerina schuberti* *Neoschwagerina simplex*		*Neoschwagerina haydeni* *Afghanella schencki* *Presumatrina schellwieni* *Neoschwagerina simplex*	Khao Khao	*Neoschwagerina craticulifera*		*Neoschwagerina margaritae*
	Kubergandian	*Cancellina cutalensis* *Armenia* *Misellina ovalis*	Gundara Kuljaho	*Armenia pamirensis* *Misellina ovalis*	Kubergandy	*Cancellina cutalensis* *Armenia salgirica* *Misellina ovalis*		*Maklaya sethaputi* *Maklaya pamirica*	Khao Phlong Phrab	*Neomisellina* cf. *lepida* *Parafusulina* cf. *granumavenae*	Sungei Sedili → Kinta Valley → Bt. Mata Ayer	*Cancellina* *Parafusulina*
	Bolorian	*Misellina parvicostata* *Misellina dyhrenfurthi*		*Misellina parvicostata* *Miselliina dyhrenfurthi*	Shyndy	*Misellina aliciae* *Perrinites* ex.gr. *hilli*		*Maklaya saraburiensis* *Misellina confragaspira*		*Misellina claudiae* *Pseudofusulina kraffti*		*Misellina claudiae*
	Yahtashian	*Chalaroschwagerina vulgaris* *Chalaroschwagerina solita*	Zygar Tchelamitchi Sateldara	*Chalaroschwagerina vulgaris* *Chalaroschwagerina solita*	Kyrkkochu	*Perrinites compressus* *Metaperrinites* aff. *cumminsi*		*Misellina otai* - *Misellina* cf. *termieri* *Monodiexodina shiptoni*	Khao	*Cuniculinella globosa* - *Eoparafusulina malayensis*		
	Sakmarian	*Robustoschwagerina* - *Paraschwagerina*	Horidzh	*Robustoschwagerina schellwieni* *Paraschwagerina mira* *Zellia heritschi*	Tashkozyk	*Böesites, Glaphyrites, Eoasianites, Svetlanoceras, Emilites*	PERMIAN Lower	*Triticites ozawai* - *Paraschwagerina yanagidai*	Ban Num Lum			(unnamed) *Pseudofusulina moelleri*
	Asselian	*Schwagerina sphaerica* - *Pseudofusulina firma* *Schwagerina moelleri* - *Pseudofusulina fecunda* *Schwagerina vulgaris* - *Schwagerina fusiformis*	Shagon	*Schwagerina sphaerica* *Dutkevitchia splendida* *Schwagerina edelsteini* *Pseudoschwagerina robusta* *Schwagerina vulgaris* *Schwagerina fusiformis*		*Conularia, Euridesma*						*Pseudoschwagerina* - *Zellia* *Triticites* *Montiparus*
CARBONIFEROUS Upper	Orenburgian				(Northern Pamir) (Lys, 1977) *Quasifusulina longissima* *Triticites* sp.		CARBONIFEROUS Upper	*Protriticites tethydis*	Ban Pha Noi		Bt. Chuping	
	Gzhelian							*Fusulina pulchella*	Huai Luang	*Fusulina konnoi*		*Fusulina* - *Fusulinella* *Profusulinella*
	Kassimovian							*Hemifusulina* (?) *thaiensis*				
Middle	Moscovian				*Fusulina mosquensis* *Fusulinella colaniae*		Middle	*Beedeina paradistenta* *Profusulinella prisca timanica*	Huai Bun Nak		Bt. Charas → Terbat (Sarawak)	*Pseudostaffella antiqua* *Pseudostaffella composita*
	Bashkirian				*Profusulinella prisca* *Neostaffella ozawai* *Eostaffella pseudostruvei*			*Profusulinella parva*		*Eostaffella mosquensis* *Millerella rossica*		*Eostaffella* - *Millerella*
Lower	Serpukhovian						Lower					
	Visean											
	Tournaisian											

Table 1.4 Correlation of biostratigraphic zonation of fusulinids in Thailand with Mediterranian-Alpine Folded Belt, Darvaz, Southeast Pamir, Malaysia, and South China (Toriyama, 1984).

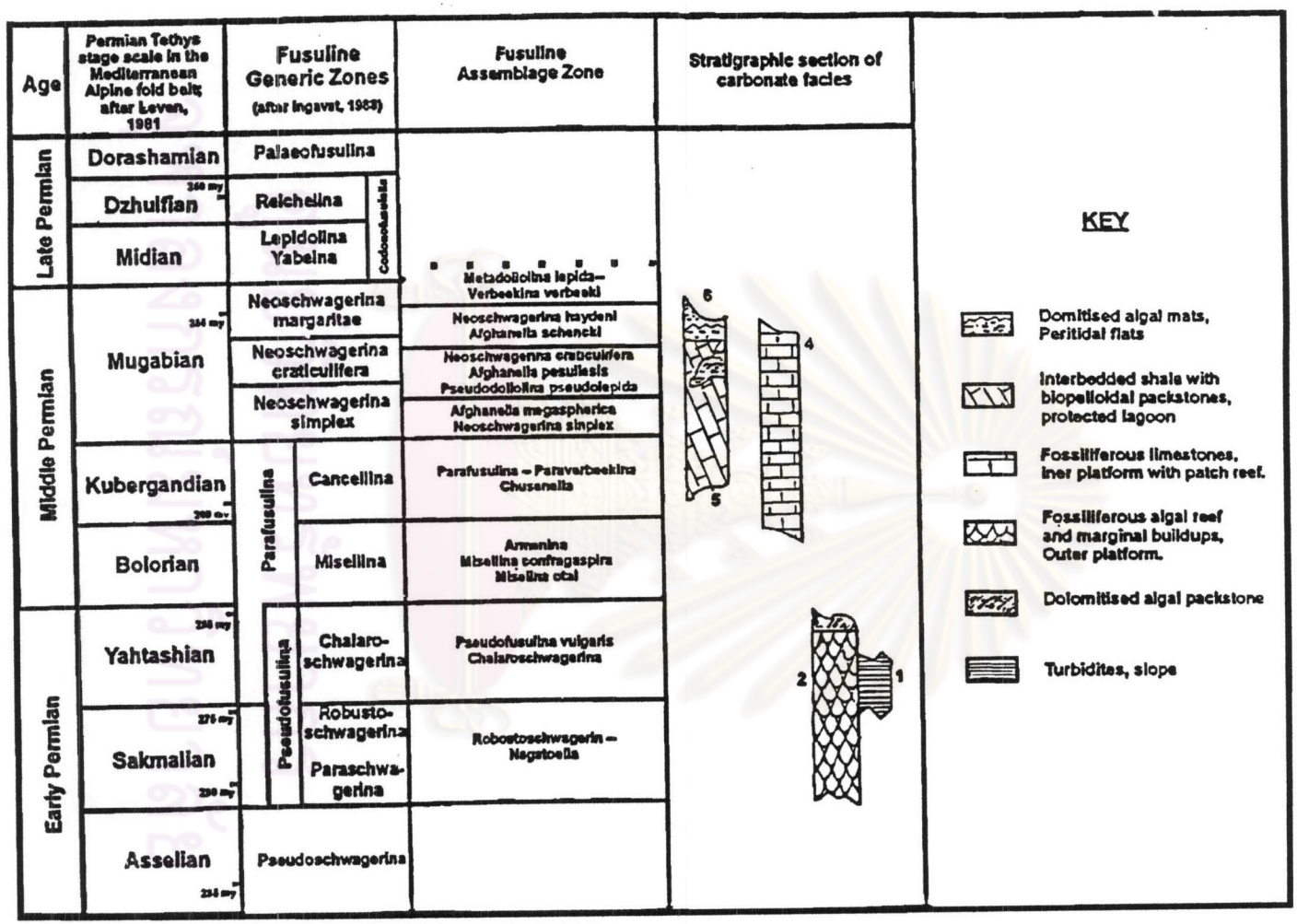

Table 1.5 Fusuline assemblage zones from Saraburi limestone (Dawson, 1991, in Dawson and Racey,1993)

SERIES		STAGES	SELECTED FOSSIL ZONES			Polarity	Ma
			Ammonoids	Conodonts	Fusulinids		
Triassic		Griesbachian	*Ophiceras* *Otoceras*	*Hindeodus parvus*			251.1
Permian	Lopingian	Changhsingian	*Pseudotirolites* *Paratirolites* *Shevyrevites* *Iranites-Phisonites*	*Clarkina changxingensis* *C.subcarinata*	*Palaeofusulina sinensis*		± 3.6 253.0
		Wuchiapingian	*Araxoceras-Konglingites* *Anderssonoceras* *Roadoceras* *Doulingoceras*	*C.orientalis* *C.leveni* *C.dukouensis* *C.postbitteri*	*Nanlingella simplex* *Codonofusiella kwangsiana*		± 0.3
	Guadalupian	Capitanian	*Timorites*	*Jinogondolella altudaensis* *J.postserrata*	*Lepidolina* *Yabeina* *Polydiexodina shumardi*		
		Wordian	*Waagenoceras*	*J.asserata*	*Neoschwagerina craticulifera*		264.1 ± 2.2
		Roadian	*Demarezites* *Stacheoceras discoidale*	*J.nankingensis*	*Praesumatrina neoschwagerinoides* *Cancellina cutalensis* *Armenina*	Illawarra Reversal	
	Cisuralian	Kungurian	*Pseudovidrioceras dunbari* *Propinacoceras busterense*	*Mesogondolella idahoensis* *Neostreptognathodus pnevi* *N.exculptus*	*Misellina claudiae* *Brevaxina dyhrenfurthi*		272.2
		Artinskian	*Uraloceras fedorowi* *Aktubinskia notabilis* *Artinskia artiensis*	*N.pequopensis* *Sweetognathus whitei* *M.bisselli*	*Pamirina* *Chalaroschwagerina vulgaris*		± 3.2 280.3
		Sakmarian	*Sakmarites inflatus* *Svetlanoceras strigosum*	*S.primus* *Streptognathodus postfusus*	*Robustoschwagerina schellwieni* *Sphaeroschwagerina sphaerica*		± 2.6
		Asselian	*S.serpentinum* *S.primore*	*S.contricius* *S.isolatus*	*S.moelleri-P.fecunda* *S.vulgaris*		290.6 ± 3.0
Carboniferous		Gzhelian	*Shumardites confessus* *Emilites plummeri*	*S.wabaunsensis* *S.elongatus*	*Daixina robusta* *D.bosbytauensis* *Triticites stuckenbergi*		300.3 ±3.2

Table 1.6 Permian Chronostratigraphic Subdivision approved by the Permian Subcommission, ICS (Yugan et al., 1997).

ICS PROPOSED CLASSIFICATION		TRADITIONAL STANDARD	REFERENCE SEQUENCES											
		SOUTHERN URALS	ARMENIA IRAN, PAMIR	SOUTH CHINA		JAPAN		SW USA	GERMANY	Palynostratigraphy	E.AUSTRALIA	W.AUSTRALIA	SALT RANGE	CANADIAN ARCTIC
LOPINGIAN	Changhsingian	UPPER ?	Dorashamian	LOPINGIAN	Changhsingian	TOYOMAN	Mitaian	?	Zhechstein	Ra	Narrabeen Gr	Faunal stages ?	? Chhidru Fm	?
	Wuchiapingian		Dzhulfian		Wuchiapingian			Ochoan		U5c	Illawarra coal measures	F Hardman Fm	Kalabagh mb	
GUADALUPIAN	Capitanian	Tatarian	Midian	YANGSINGIAN MAOKOUAN	Lengwuan	KANOKURAN	Kuman	GUADALUPIAN Capitanian	Elbe		Gerringong volcarucs	Condren Ss	Wargal Fm	Degerbols Fm
	Wordian	Kazanian	Murgabian		Kuhfengian		Akasakan	Wordian	Havel	U5b	Berry Fm			
	Roadian	Ufimian	Kubergandian	CHIHSIAN	Xiangboan	SAKAMOTOZAWAN	Nabeyaman	Roadian			Nowra Ss	E Binthalya Fm	ZALUCH GROUP Amb Fm	Trold Fiord Fm
CISURALIAN	Kungurian	LOWER Kungurian	Bolorian		Luodianian				Eisenach Fm	U5a	Wandrawandun Siltstone	D2 Mungadan Fm		Assistance Fm
	Artinskian	Artinskian	Yahtashian	CHUANSHANIAN	Longlinian		Kabayaman	LEONARDIAN Cathedralian	Tambach Fm			Coolkilya Ss		
	Sakmarian	Sakmarian	Sakmarian		Zisongian		Kawaguchian	Hessian	LOTLIEGEND Rotterade Fm	U4	Snapper Point Fm	D1 Byro Gr	NILAWAHAN GROUP Sardhai Fm	Great Bear Cape Fm
	Asselian	Asselian	Asselian			Nagatoan		WOLFCAMPIAN Lenoxian				C Wooramel Gr		
									Oberhof Fm	L4	Pebbly Beach Fm	B Callytharra Fm	Warcha Fm	Rannes Fm
								Nealian	Goldlantel Fm	3a-b	Allandale Fm	A Carrandibby Fm	Dandot Fm	Belcher Channel Fm
									Manebach Fm		Lochinvar Fm	Lions Gr	Tobra Fm	
SCPS, 1996		Chuvashov, 1993	Leven et al., 1993	Sheng & Jin, 1994		Minato et al., 1978		Ross & Ross, 1987	Menning, 1995	Archbold & Dickins, 1991			Wardlaw & Pogue, 1995	Nassichuk, 1995

Table 1.7 Correlation of selected Permian Successtions adopted from many authors (Yugan et al., 1997)