CHAPTER I

INTRODUCTION

Fusulinoidean fauna is useful for determining the age of carbonate rocks, and for biostratigraphic correlation. Fusulinoidea lived in Late Mississippian (Carboniferous) to Late Permian. It is a large group of extinct foraminifera, single-celled organisms related to amoebas but having complex shells that are easily preserved as fossils. The fusulinoidea is a good index fossil of Permian time because abundance and many phylogenetic lineages, short geologic range, widespread distribution and rapid evolution. Fusulinoidea have been extremely useful for correlating different rock units in widely separated regions and for dividing geologic time into smaller units.

The carbonate rocks in Amphoe Ta Khli (Amphoe means district in Thai), Amphoe Tak Fa and Amphoe Phayuha Khiri, east of Changwat Nakhon Sawan (Changwat mean province in Thai) were grouped as the Tak Fa formation of the Saraburi Group (Nakornsri, 1977, 1981). They are composed of various groups of fossil for example fusulinoideans, smaller foraminifers, coral, algae, ammonoid. The fusulinoideans in this area are abundant and need more investigation in detail. Their lithostratigraphic and biostratigraphic information of limestone in this area is very poor. So, this study will be the first to provide the detailed biostratigraphic work of Middle Permian in the Nakhon Sawan area. Furthermore, this research can be tool for stratigraphic correlation and discussion about the carbonate development in this area and adjacent regions.

1.1 The study area

1.1.1 Location

The study area is located in Amphoe Ta Khli, Amphoe Tak Fa and Amphoe Phayuha Khiri, Changwat Nakhon Sawan. It is about 220 km north of Bangkok (Figure1.1) and bounded by latitudes 15°25′ to 15°05′N and longitude 100°15′ to 100°35′E. The

study area is located within the topographic map scale 1:50,000 of the Royal Thai Survey Department, of sheet 5039 I, II, 5139 IV and 5040 II, series L7017, Amphoe Ta Khli, Amphoe Inn Buri, Ban Khok Samran and Amphoe Tha Tako respectively and the geologic map scale 1:250,000 Sheet ND47-3 (Changwat Nakhon Sawan) (Figure 1.2).

1.1.2 Accessibility

The study area can be accessed by car from Bangkok to Nakhon Sawan taking highway No.1 (Phahol Yothin Highway) till Amphoe Bang Pa-In, using highway No.32 (Asia Highway) via Phranakhon Si Ayutthaya, Angthong, Sing Buri, Chainat and Uthai Thani into Nakhon Sawan for 3 hours. The total distance from Bangkok to Amphoe Muang, Changwat Nakhon Sawan is about 240 kilometers (Figure 1.3). Going straight along route no.32 until meet the Chainat Junction is recommended, then turn right and follows the route no.1 to Amphoe Ta Khli and Amphoe Tak Fa and turn right at Naeon Ma-Kok Junction and follows the route no.3327 to Amphoe Phayuha Khiri.

1.1.3 Physiography and climate

The study area is located on the eastern part of Changwat Nakhon Sawan. The physiographic of the study area consists of flat low land especially in Amphoe Phayuha Khiri, undulating terrain and many isolated limestone hills laying NW-SE trend and scatter exposed in Amphoe Ta Khli and Amphoe Tak Fa. The average elevation of the study area is between 50-150 meters above mean sea level. The main river catchments in this area are bounded by the Mae Ping River and the Yom River. Later, they joined into the Chao Phraya River which flows southernly to the Gulf of Thailand and meanders across the vast central plain.

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 mean annual rainfall is 1182.6 millimeters during the year 1996 to 2000. The average annual temperature is 28.3 ^{o}C during the year 1999 to 2003.

1.2 Purposes of study

1. To give detailed description of Permian fusulinoidean fauna from Amphoe Ta Khli, Amphoe Tak Fa and Amphoe Phyuha Khiri, eastern part of Changwat Nakhon Sawan.

2. To establish the biostratigraphic framework in study area.

3. To study the depositional environment and age determination of carbonate rocks within the investigated areas.

1.3 Methodology

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

1.3.1 Office work

The office work includes the review on previous works of fusulinoideas and biostratigraphy, topographic and geologic maps of the study area and adjacent regions.

1.3.2 Field work

The field investigations are focused on the continuous of carbonate section and the isolated carbonate localities. Two carbonate sections have been investigated: Khao Look Klone and Khao Noi section. I systematically collected the carbonate samples every 1 m through the section. All 67 samples have been picked up for laboratory work. Ten isolated localities of carbonates yielding fusulinoidea were collected from Amphoe Ta Khli, Amphoe Tak Fa and Amphoe Phrayuha Khiri, east of Changwat Nakhon Sawan. I collected six carbonate samples in Amphoe Ta Khli. They are from Ban Hua Khao, Khao Mun Nak, Khao Kui, Khao Thong, Khao Sung and Khao Chong Lom. In Amphoe Tak Fa, three carbonate rocks were collected from Khao Nam Ving, Khao Ploi and Khao Kra Jaeow. And only one sample in Amphoe Phrayuha Khiri was collected from Khao Noom Nang. The sampling provides lithological samples exhibiting texture, structure and fossil on a hand specimen scale and samples for paleontological studies. Because

the methods used in laboratory investigations may not yet be certain at the time of sampling, large sized samples were collected for several medium to large scale thin sections to be prepared and fusulinoideas to be studied. The size 5x4, 5x5 and large up to 20x15 cm have proved useful as formats for thin sections used in carbonate petrography and paleontology identifications (Flugel, 2004).

1.3.3 Laboratory work

In laboratory, about 1,000 thin-sections of carbonate rock have been prepared for carbonate petrography and paleontology identifications. Taking the photographs of fusulinoidea and carbonate texture must be done. The classification of limestone in this study is based on Dunham's classification (Dunham, 1962) which is based on composition and texture types. The figures of fusulinoidean fauna will be prepared. Their identification, age determination and biostratigraphy will be made based on all know ledges from previous works.

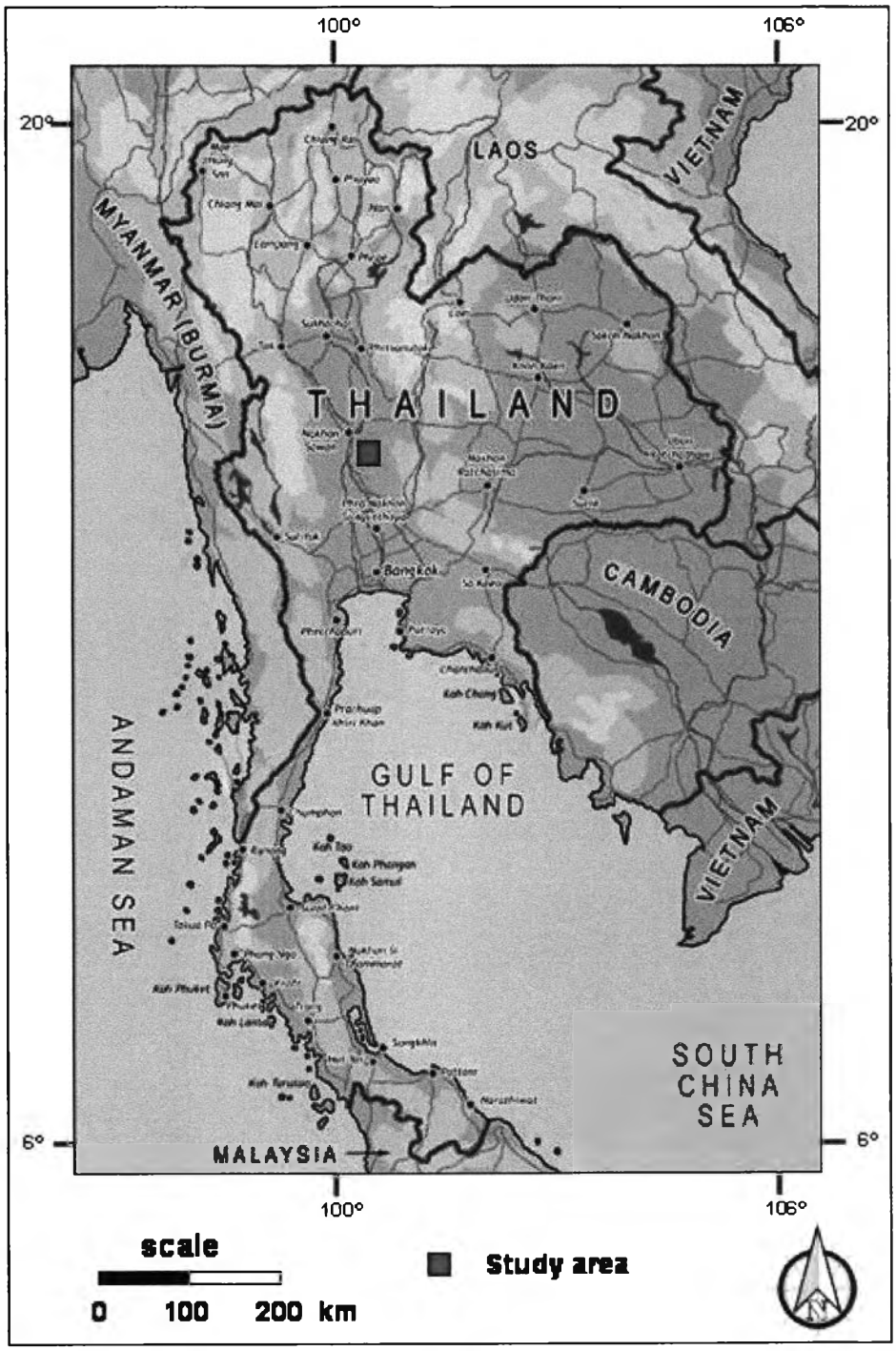

Figure 1.1 Index map of Thailand shows the study area in Changwat Nakhon Sawan.

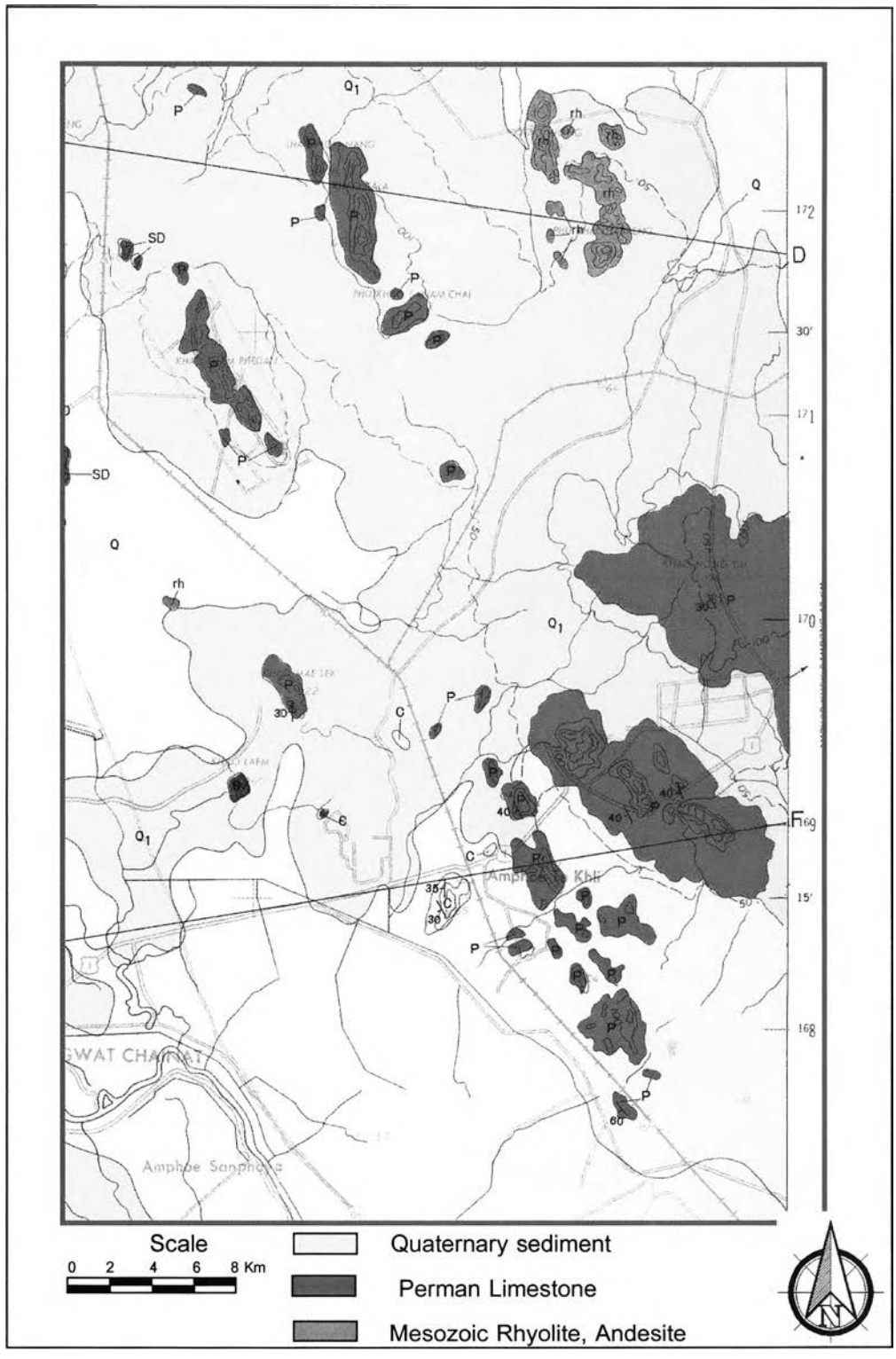

Figure 1.2 Geologic map of Changwat Nakhon Sawan ND 47-3 Scale 1:250,000 (DMR, 1976).

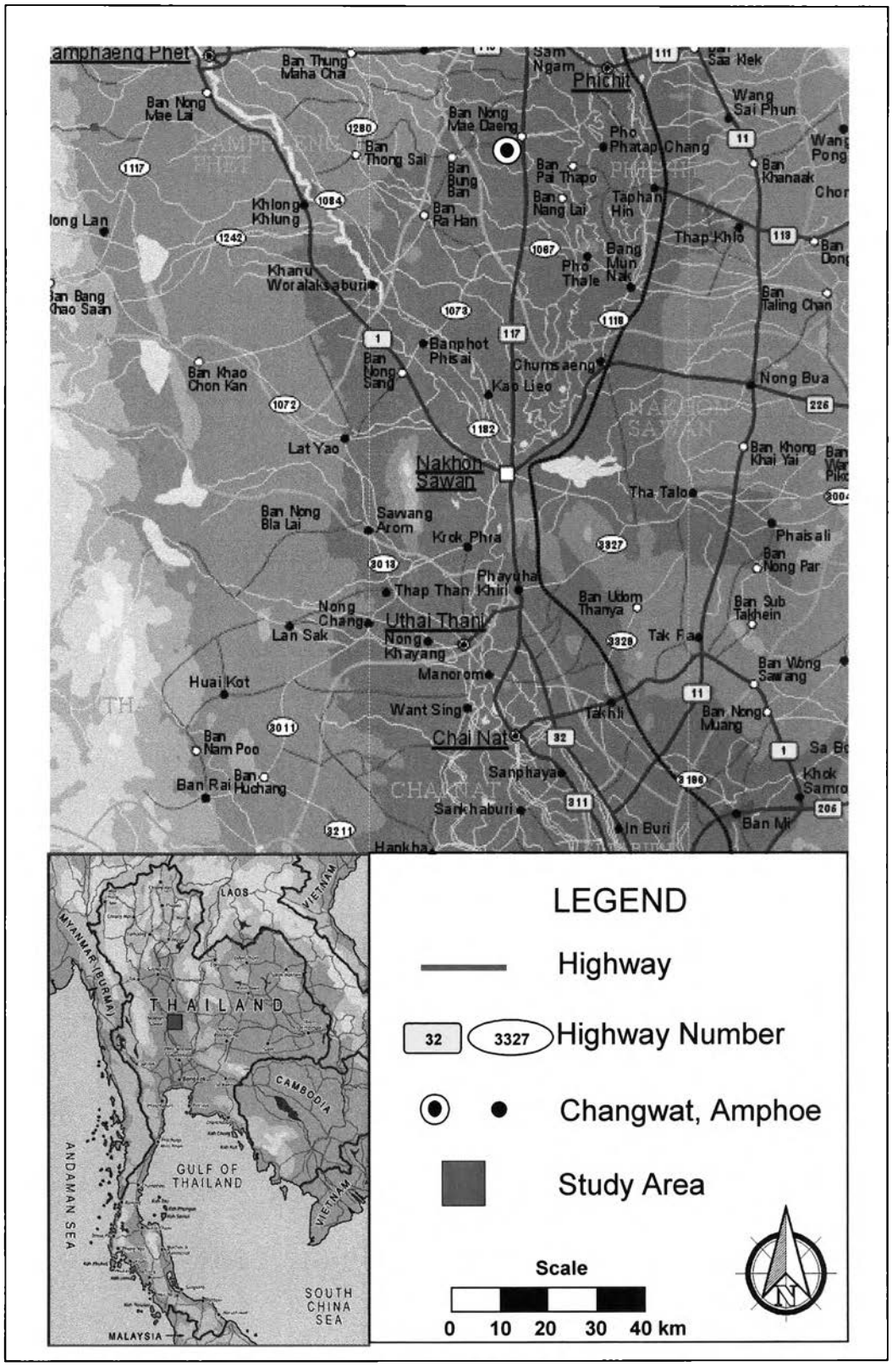

Figure 1.3 A route map showing the accessibility to study area (Changwat Nakhon Sawan).

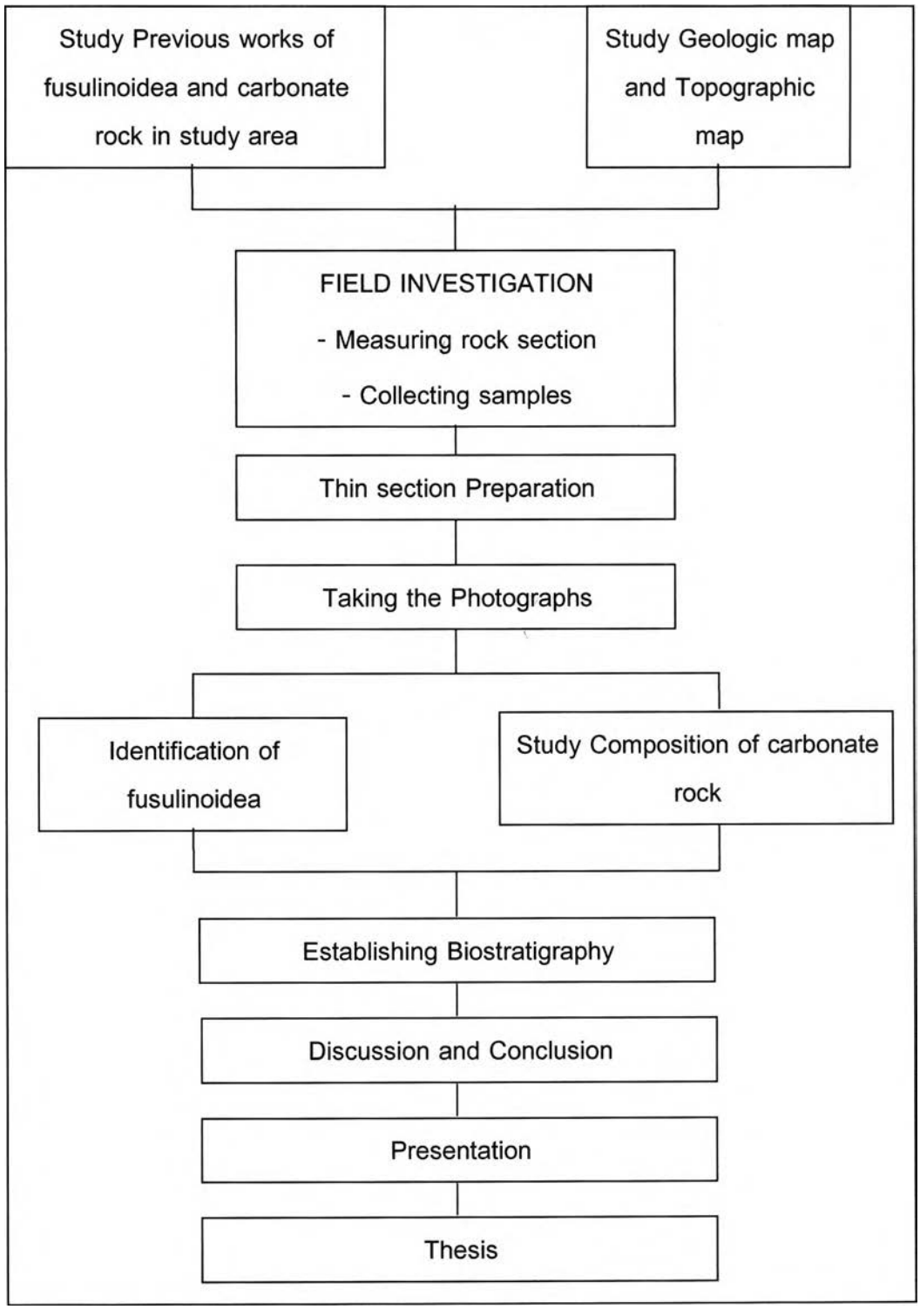

Figure 1.4 Flow chart showing the Methods of the study.

1.4 Previous investigations

According to Geologic map scale 1:250,000 map sheet Changwat Nakhon Sawan, the study area is a part of Rat Buri Limestone (DMR, 1976). Later, Bunopas (1981) and Hinthong *et al.* (1985) submitted the Saraburi Group for the sequence of limestone and clastic rocks cropping out on the eastern side of lower Chao Phraya central plain from south of Nakhon Sawan. Therefore, the study area is lithostratigraphically in the Tak Fa formation of the Saraburi Group. The age of Tak Fa formation is Middle Permian (Artinskian-Kungurian). The Saraburi Group was previously mapped as the Rat Buri Group (Brown *et al.*, 1951; Javanaphet, 1969; Nakornsri, 1977). Its detailed geology will be reportd in Chapter II.

Fusulinoidean studies in Thailand has been done since 1939, Dunbar was the first paleontologist who studied fusulinoidea in Thailand. He reported the occurrence of Middle Permian fusulinoideas in limestone at Ban Dara junction, central north Thailand. Later, many paleontologists reported about fusulinoidea studies in many provinces of Thailand.

In central Thailand Pitakpaivan (1966) described fusulinoidean species *Schwagerina crassa padengensis* (Lange), *Schwagerina* cf. *tchenkianensis* (Deprat) and *Schwagerina* sp. A from Khao Sanamjang, Changwat Lop Buri. He concluded that this limestone is Artinskian to Upper Sakmarian-Artinskian in age. The stratigraphic succession and characteristic fusulinoidean genera of the Rat Buri limestone around the Khao Sanamjang area is shown in Table 1.1 Kanmera and Toriyama (1968) identified fusulinoideas from Permian Ratburi Group at Khao Phlong Phrab, Changwat Saraburi. The fusulinoidean species are *Ozawainella, Nankinella, Schubertella, Neofusulinella, Pseudofusulina, Parafusulina, Chusenella, Misellina, Cancellina, Neoschwagerina, Verbeekina, Thailandina* and *Neothailandina.*

Toriyama and Pitakpaivan (1973) collected seven fusulinoidean species from Wat Kirinakratanaram, Changwat Lop Buri: *Nankinella, Neofusulinella, Parafusulina, Verbeekina, Pseudodoliolina and Sumatrina*.

Toriyama *et al.*, (1974) reported the biostratigraphic zonation of Khao Phlong Phrab section and Khao Khao section, Changwat Saraburi. These two sections covered a stratigraphic succession ranging from the *Misellina* zone to the *Neoschwagerina* zone. They were assigned as the standard biostratigraphic sequence in the upper Lower to middle Middle Permian strata in Thailand. They also correlated the Khao Khao and Khao Phlong Prab sections with the selected sequence in the eastern part of Tethys: Pamir, Cambodia, South China, Kuma Kyushu Japan, Akiyoshi southwest Japan and Akasaka-central Japan (Table1.2).

Ingavat, Muanlek and Udomratn (1975) described three species of fusulinoideas from limestone in Amphoe Ban Rai, west of Changwat U-thai Thani. They concluded that the fusulinoideas indicate Middle to Upper Permian.

Toriyama and Kanmera (1976) found *Yangchienia, Parafusulina, Chusenella, Misellina, Verbeekina, Pseudodoliolina, Sumatrina* and *Colania* from Khao Phlong Phrab, Changwat Saraburi.

Toriyama and Kanmera (1979) divided Khao Khao Formation into four biostratigraphic zonation based on the specific assemblage of fusulinoidea: *Afghanella megaspherica-Neoschwagerina* cf. *kueichowensis* zone, *Afghanella pesuliensis-Pseudodoliolina pseudolepida* zone, *Afghanella schencki schencki* zone and *Neoschwagerina haydeni* zone.

Ingavat, Toriyama and Pitakpaivan (1980) established the fusulinoidean zonation and faunal characteristics of the Rat Buri limestone (Saraburi Group at present) in Thailand and its equivalents in Malaysia of Carboniferous and Permian age (Table 1.3) and correlated with Transcaucasia, Iran, Southeast Pamir, Afghanistan, Pakistan, Malaysia, Indochina, South China, Southwest Japan and other previous research in Thailand (Table 1.4).

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

Dawson and Racey (1993) reported the paleoenvironments of the Permian Ratburi Limestone in central Thailand through the integration of algal, fusuline and sedimentological data. This paper concluded that the fusulinoidean faunas from the Ratburi Limestone (Saraburi Group at present) in Saraburi can be divided into six main groups: *Ozawainellids*, *Staffellinids and Schubertillids*, *Schwagerinids*, *Verbeekinids*, *Neoschwagerinids* and other foraminifers, respectively.

Wielchowsky and Young (1985) presented regional facies variations in Permian rocks of Phetchabun Fold and Thrust Belt. And they studied fusulinoidea in many localities of Tak Fa formation (Table 1.5).

Permian fusulinoidean in Changwat Lop Buri and Changwat Saraburi were reported by DMR (1992). They found genus *Pseudoschwagerina*, *Parafusulina*, Schwagerinid and *Conodofusiella*. Later in 1993, DMR reported Permian fusulinoidean genus *Parafusulina*, *Paleotextularis*, *Climacammina*, *Paeudofusulina*, *Schwagerina*, *Schubertella*, *Neofusulinella*, *Boultonia*, *Staffella*, *Schwagerina*, *Nankinella*, *Yangchienia*, *Pseudodoliolina*, *Colania*, *Verbeekina*, *Chusenella*, *Minojapanella*, *Neoschwagerina*, *Sumatrina* and *Presumatrina* from Changwat Lop Buri. And reported genus *Schubetella*, *Neoschwagerina*, *Verbeekina*, *Pseudodoliolina*, *Presumatrina*, *Neofusulinella*, *Afghanella*, *Lepidolina*, *Sumatrina* and Schwagerinid from Changwat Lop Buri.

The fusulinoidean zonations in the adjacent areas have been established by many researchers. Toriyama *et al.* (1975) studied and collected data about fusulinoidean biostratigraphic zonation in Thailand and Malaysia. They designated that these zones range from Middle Carboniferous to Middle Permian (Table 1.6).

Toriyama (1984) summarized the fusulinoidean faunas in Thailand and Malaysia. He also correlated biostratigraphic zonation of fusulinoideas in Thailand with Mediterranian-Alpine Folded Belt, Darvaz, Southeast Pamir, Malaysia and South China (Table1.7).

Ingavat (1984) correlated the fusulinoidean fauna records the studied from western, central and eastern provinces in Thailand. This research is illustrated in Table 1.8.

Ueno (1996) correlated fusulinacean biostratigraphy in the Akiyoshi Limestone Group with the Permian standard zonation in the Tethys region and special attention to the verbeekinid and neoschwagerinid fusulinacean biostratigraphy and their early evolution (Table 1.9, 1.10 and Figure 1.6).

Charoentitirat (2002) established fusulinoidean standard zonations in the Indochina Block of Thailand (Table 1.11)

The detailed study of fusulinoidea especially in Changwat Nakhon Sawan, investigated area, has been reported by a few researchers. Pitakpaivan (1965) identified fusulinoidea 3 species i.e. *Sphaerulina* sp., *Ozawainella* sp. and *Neofusulinell*a sp. from the limestone of Chondhurian, Amphoe Ta Khli, Changwat Nakhon Sawan. They concluded that the limestone in this area is Artinskian age.

Jung-u-suk (1993) reported Permian fusulinoidean species such as *Nankinella* sp., *Pisolina?* sp., *Neofusulinella* sp. *Schubertella*? sp. and Middle Permian fusulinoideas: *Verbeekina* sp., *Verbeekina verbeeki*, *Neoschwagerina* sp., *Presumatrina* sp., *Nankinella* sp., *Colania*? sp., *Afghanella* sp., *Staffella* sp., *Parafusulina* sp. and schwagerinid from Amphoe Tak Fa, Changwat Nakhon Sawan.

1.5 The Permian chronostrarigraphic subdivisions

The construction of Geologic Time Scale 2004 (Table 1.12) incorporated different techniques depending on the data available within each interval (Gradstein and Ogg, 2004). It must be applied for determining the zones of the 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. There 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 (Yugen *et al.*, 1997). For convenience of the readers, the author would like to show the correlation of selected Permian succession which are adopted from many authors' contributations as shown in Table 1.13.

Table 1.1 The stratigraphical succession and characteristic fusulinoidea genera of the Saraburi limestone (Pitakpaivan, 1966).

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	*Sphaerulina* and *Neofusulinella*
	The limestone of Kao Sanamjang	*Schwagerina*
Sakmarian	The limestone of Noankowtok	*Pseudoschwagerina*

Table 1.4 Fusulinoidea zonations in Thailand compare with Transcaucasia, Iran (Abadeh), Southeast Pamir, Afghanistan, Pakistan, Malaysia, Indochina, South China, Southwest China

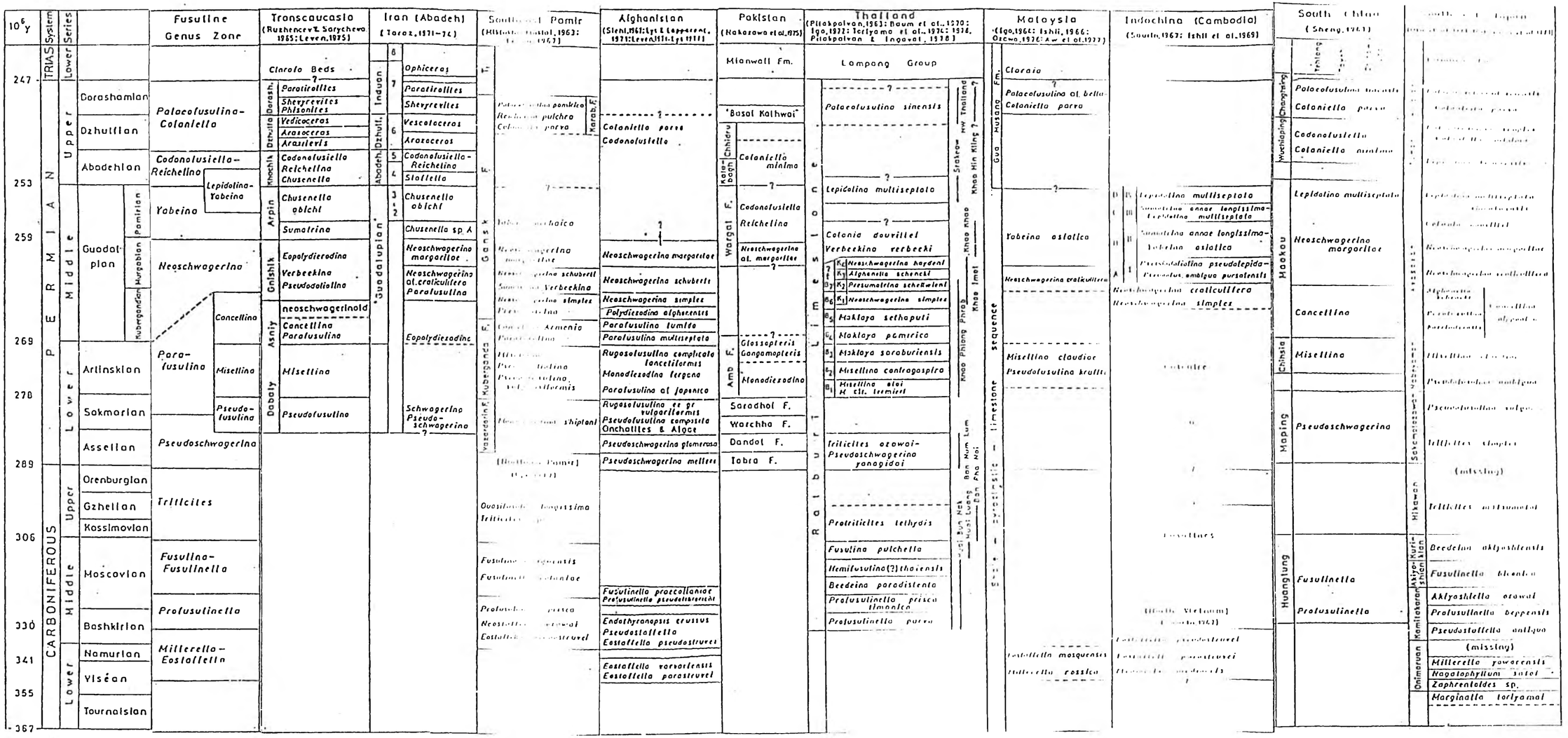

Table 1.3 Fusulinoidea zonations of Saraburi Group in Thailand and its equivalents in Malaysia (Ingavat et al., 1980).

System	Series	Fusuline Zonation
PERMIAN	Upper	*Palaeofusulina* aff. *bella* – *Colaniella parva* zone
	Middle	*Lepidolina multiseptata multiseptata* zone *Colania douvillei* – *Verbeekina verbeeki* zone *Neoschwagerina haydeni* zone *Afghanella schencki schencki* zone *Presumatrina schellwieni* zone *Neoschwagerina simplex* zone *Maklaya sethaputi* zone *Maklaya pamirica* zone
	Lower	*Maklaya saraburiensis* *Misellina otoi* – *Misellina termieri* zone (missing?) *Triticites ozawai* – *Paraschwagerina yanagidai* zone
CARBONIFEROUS	Upper	(missing?) *Protriticites tethydis* zone
	Middle	*Fusulina pulchella* zone *Hemifusulina* (?) *thaiensis* zone *Beedeina paradistenta* zone *Profusulinella prisca timanica* zone *Profusulinella parva* zone
	Lower	(missing?) *Eostaffella mosquensis* – *Millerella rossica* zone

Table 1.6 Fusulinoidea zonations of Thailand correlated with Southeast Pamir, Burma (Shan State), Cambodia, South China, South Kyushu and Akiyoshi Japan (Toriyama et al., 1975).

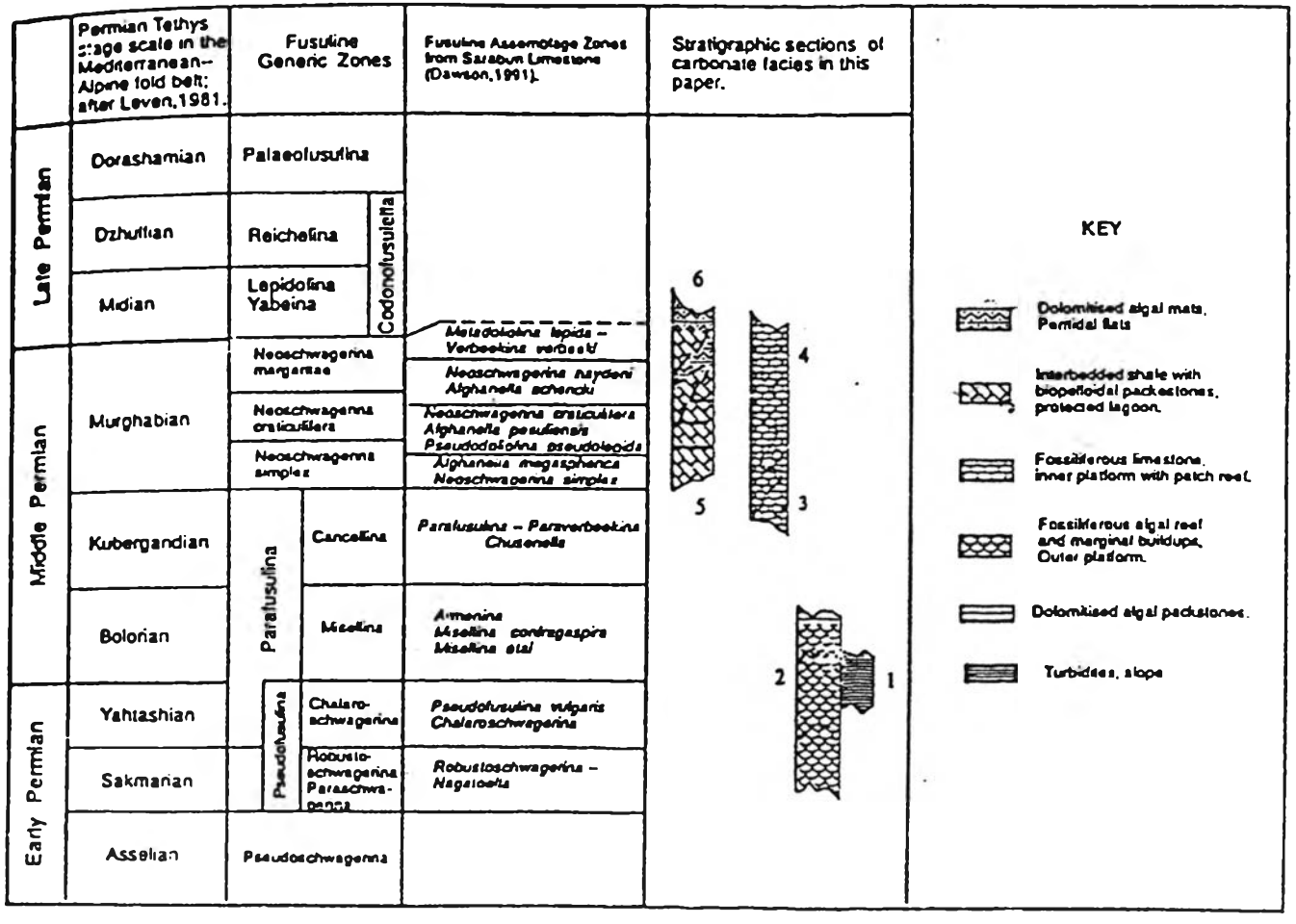

Figure 1.5 Fusulinoidea assemblage zones from Saraburi Limestone (Dawson and Racey, 1993).

Table 1.5 Selected representative fusulinoidea faunas in Permian rock of Phetchabun fold and thrust belt (Wielchowsky and Young, 1985).

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* Monkawa 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., *Tharlandina* 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. *gruperaensis-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. *hayderi* 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 cayeuxi* (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 1.6 Fusulinoidea zonations of Thailand correlated with Southeast Pamir, Burma (Shan state), Cambodia, South China, South Kyushu and Akiyoshi Japan (Toriyama et al., 1975).

Table 1.7 Correlation of biostratigraphic zonation of fusulinoidea in Thailand with Mediterranian-Alpine Fold Belt, Darvaz, Southeast Pamir, Malaysia and South China (Toriyama, 1984)

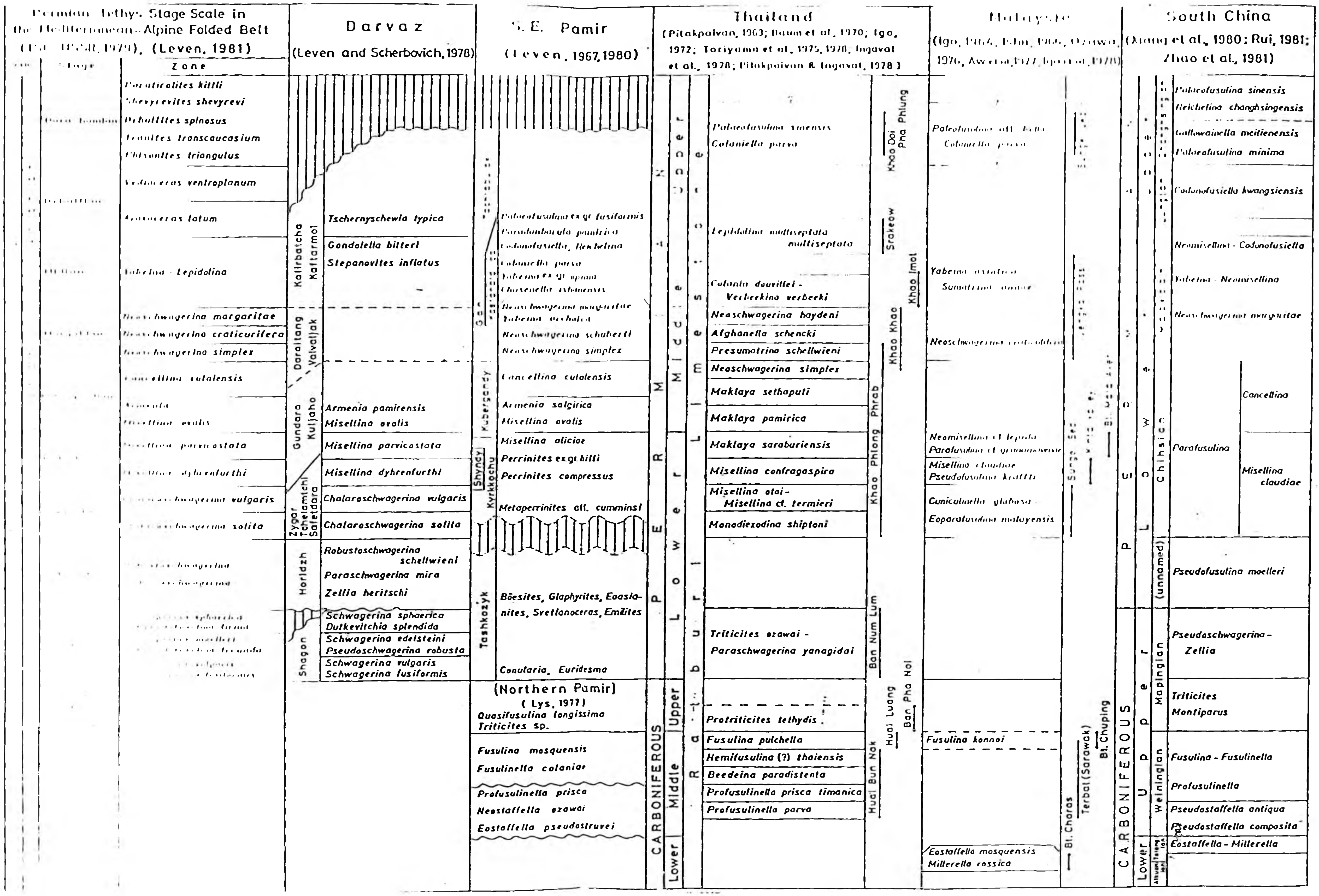

Table 1.8 Zonation and correlation on foraminiferal faunas from the western, central and eastern provinces in Thailand (Ingavat, 1984)

System	Stage (Leven 1981)	Fusulinid zone		Thailand Pitakpaivan 1963, Bassoullet 1973 Iga 1972, Fontaine et. al 1974, 1978, Pitakpaivan & Ingavat 1978, Ingavat & Douglass 1980, Sakagami 1982	Fossil Location of Western Province	Fossil Location of Central Province	Fossil Location of Eastern Province
UPPER PERMIAN	Dorashamian	*Palaeofusulina*		*Colaniella parva*		Doi Pha Phlung fauna Nan fauna Phrae fauna	
	Dzhulfian	*Reichelina*	*Codonofusiella*	*Shanita intermedia* ?	Rhlong Phra Sueng fauna Phanguga fauna		
	Midian	*Lepidolina* *Yabeina*	*Codonofusiella*	*Lepidolina multiseptata* *Codonofusiella*			
MIDDLE PERMIAN	Murgabian	*Neoschwagerina*		*Colaniella douvillei, Yabeina vachardi* K4 *Neoschwagerina haydeni* K3 *Afghanella schencki* B7 K2 *Presumatrina schellwieni* B6 K1 *Neoschwagerina simplex*	Sai Kum Pang fauna Mae Sariang fauna		
	Kubergandian	*Cancellina*		B5 *Maklaya sethapoli* B4 *Maklaya pandoli* B3 *Maklaya saccharaensis*	Sri Racha fauna Ban Na San fauna Rat Buri fauna Umphang fauna	Phrae fauna	
	Bolorian	*Parafusulina*	*Misellina*	B2 *Misellina confusa opima* B1 *Misellina ozawai* *M. cfr. termieri*	Sai Yok fauna		
LOWER PERMIAN	Yahtashian	*Parafusulina* / *Pseudofusulina*	*Chalaroschwagerina*	*Monodiexodina sheplani* *M. sutchanica*	Sri Sawat fauna Mae Sariang fauna Mae Ramad fauna Chiang Dao fauna		
	Sakmarian	*Pseudofusulina*	*Robustoschwagerina* *Paraschwagerina*	*Robustoschwagerina tenuiseptata*	Pak Tho fauna Pra Chuab Kiri Khan fauna Chumphon fauna Surat Thani fauna		
	Asselian	*Pseudoschwagerina*		*Triticites ventricosus* *Pseudoschwagerina campbelli*	Doi Huato fauna Pai fauna Phrae fauna	Klu Lom fauna	

Table 1.9 Correlation of fusulinacean biohorizones and biozones in the Akiyoshi Limestone Group with the Tethyan standard zonation scheme (Ueno, 1996).

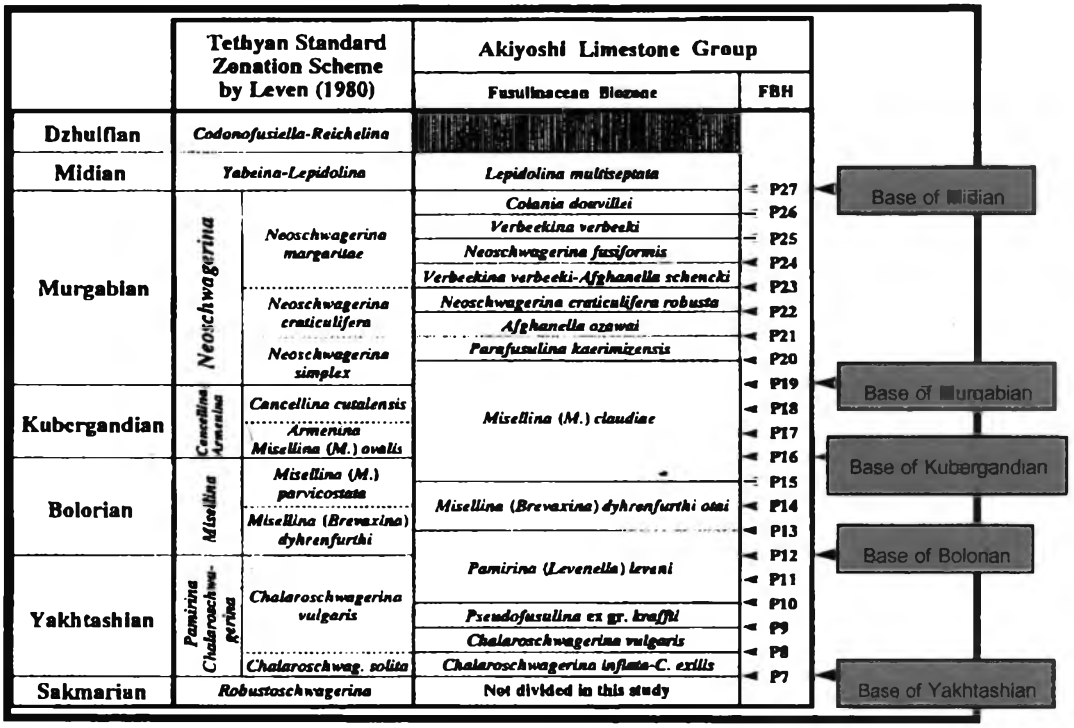

Table 1.10 Permian subdivisions of the Tethys and Panthalassa regions (Ueno, 1996).

System	Standard Stage		Leven (1975)	Leven (1992)		Tethys-Panthalassa Standard (This study)		
	Tethys	Urals	Series	Series	Sub-series	Series	Stage	Important fusulinacean genera
Permian	Dorashamian	?	Arian (Late)	Late	Late	Late	Dorashamian	*Palaeofusulina Gallowayinella*
	Dzhulfian	Tatarian					Dzhulfian	*Codonofusiella Reichelina*
	Midian	Kazanian			Early	Middle	Midian	*Lepidolina, Yabeina Sumatrina*
	Murgabian	Ufimian	Kushan (Middle)				Murgabian	*Neoschwagerina Colania, Afghanella*
	Kubergandian						Kubergandian	*Maklaya, Cancellina Armenina*
	Bolorian	Kungurian		Early	Late		Bolorian	*Misellina*
	Yakhtashian	Artinskian	Yaik (Early)			Early	Yakhtashian	*Pamirina Chalaroschwagerina*
	Sakmarian	Sakmarian			Early		Sakmarian	*Robustoschwagerina*
	Asselian	Asselian					Asselian	*Sphaeroschwagerina Pseudoschwagerina*

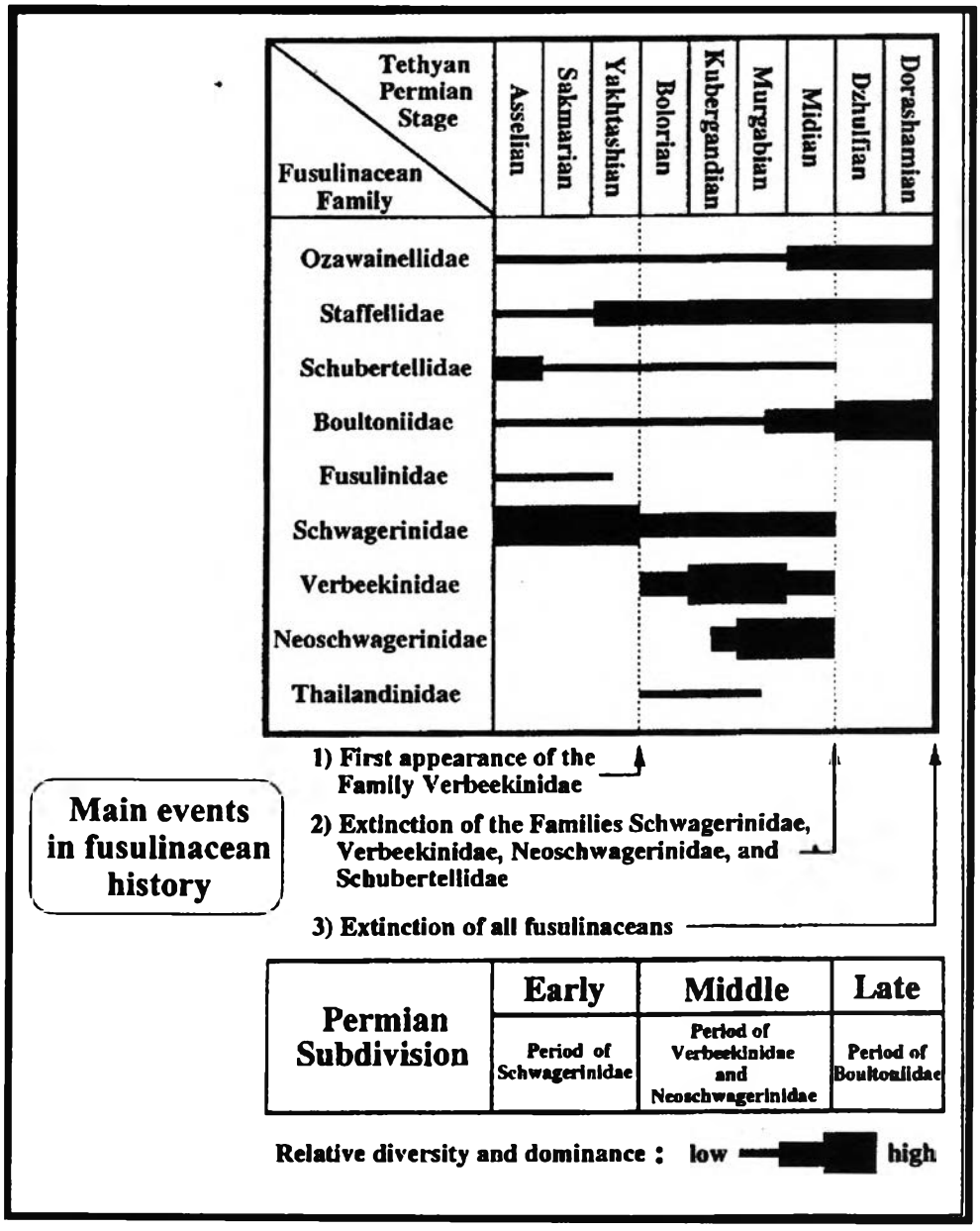

Figure 1.6 Relative diversity and dominance, and general history and events of Permian fusulinaceans in the Tethys and Panthalassa regions (Ueno, 1996).

Table 1.11 Fusulinoidean Standard Zonations in the Indochina Block of Thailand (Charoentitirat, 2002).

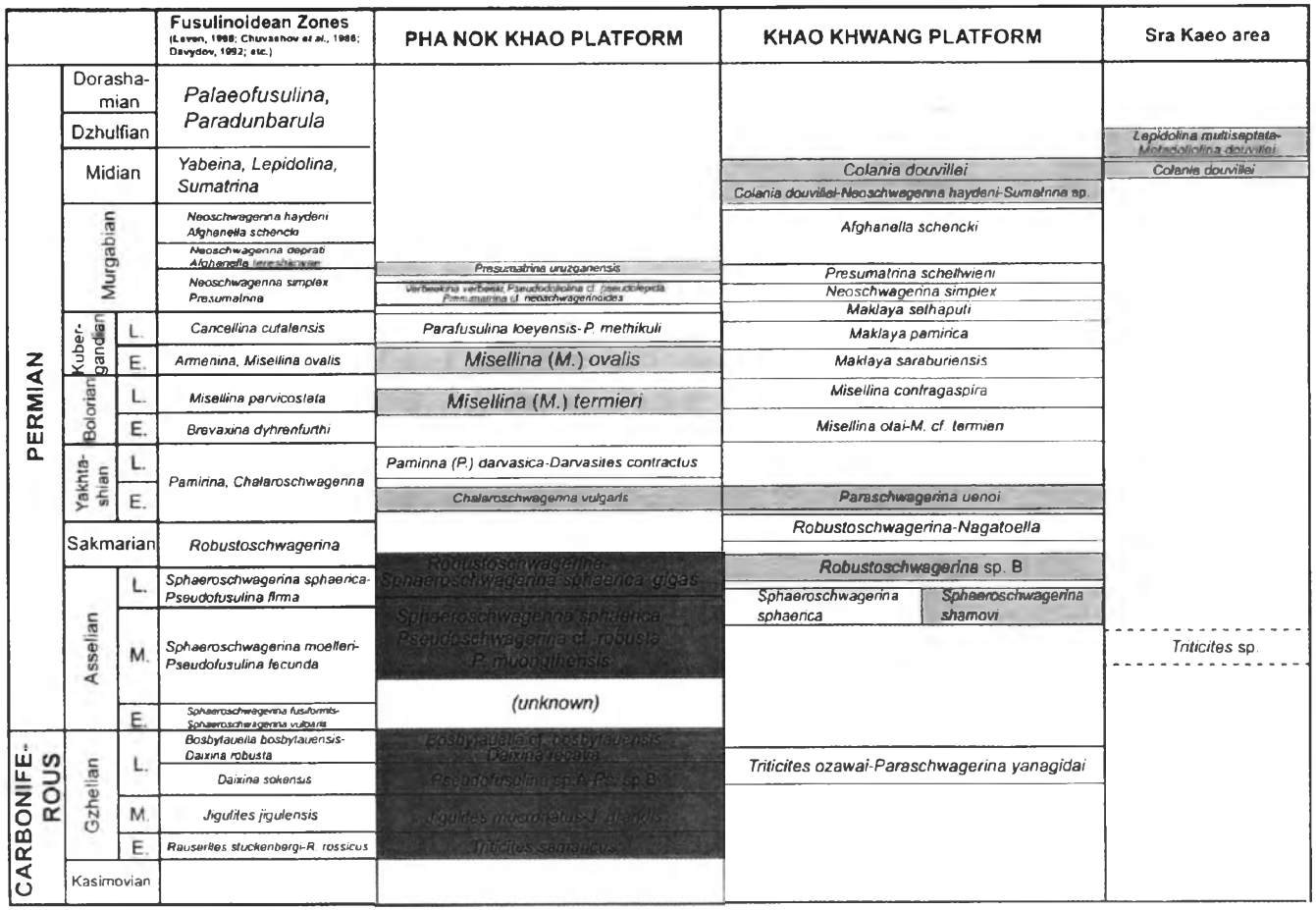

Table 1.12 Geological Time Scale 2004 (Gradstein and Ogg, 2004).

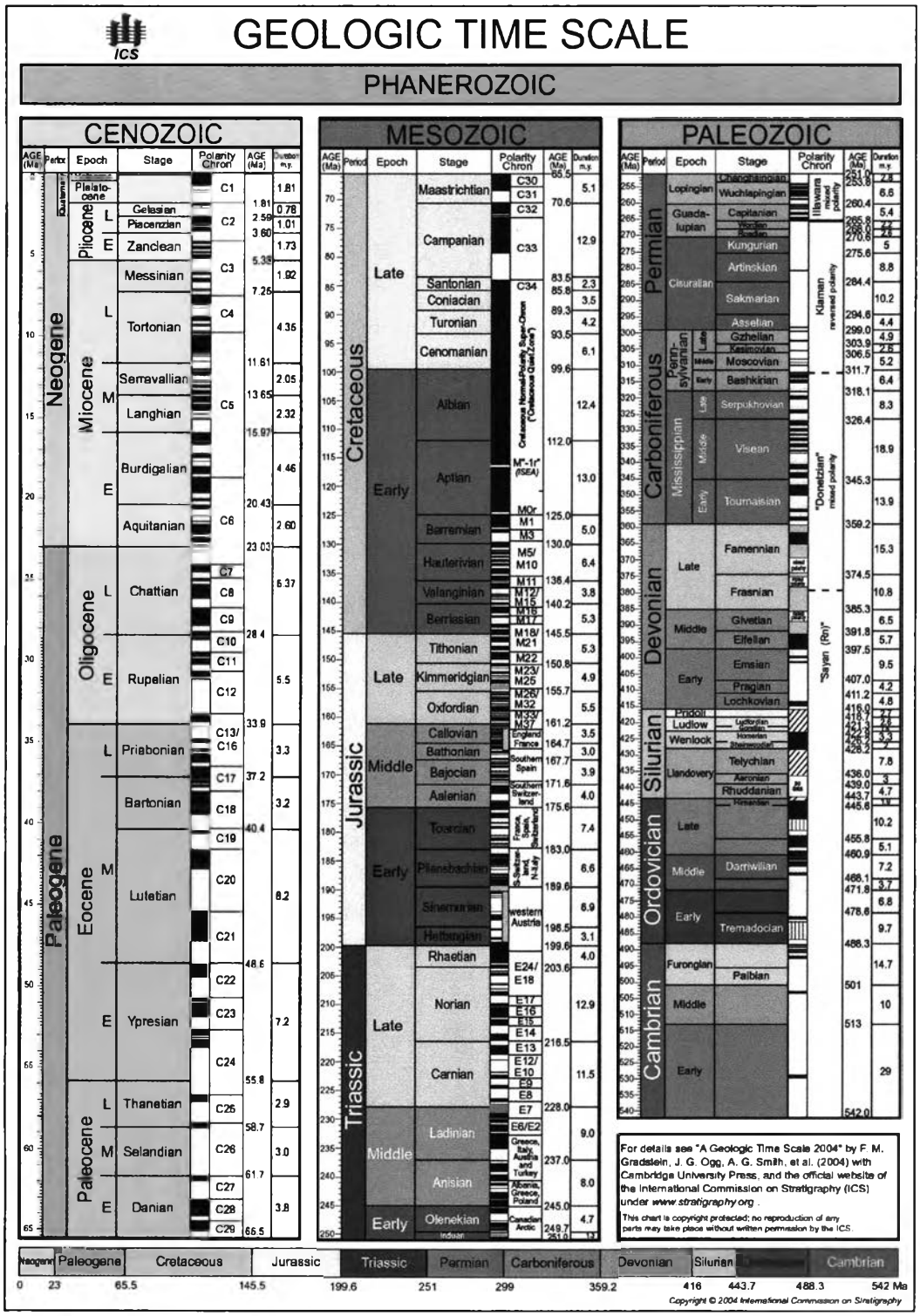

Table 1.13 Correlation of selected Permian Succession adopted from many authors (Yugen et al., 1997).

ICS PROPOSED CLASSIFICATION		TRADITIONAL STANDARD	REFERENCE SEQUENCES									
		SOUTHERN URALS	ARMENIA IRAN, PAMIR	SOUTH CHINA		JAPAN	SW USA	GERMANY	E.AUSTRALIA	W.AUSTRALIA	TAETHANGE	CANADIAN ARCTIC
LOPINGIAN	Changhsingian	UPPER	Dorashamian	LOPINGIAN	Changhsingian	TOYONAN						
	Wuchiapingian		Dzhulfian		Wuchiapingian		Mitaian		Ria			
GUADALUPIAN	Capitanian		Midian	YANGSINGIAN	MAOKOUAN Lengwuan		Kuman	Zechstein	Narrabeen Gr		Clinton Fm	
	Wordian	Tatarian	Murgabian		Kuhfengian	KANOKURAN	Akasakan		U5c Illawarra coal measures		Hardman Fm	Wapiti Fm
	Roadian	Kazanian	Kubergandian	CHHSIAN	Xiangboan		Nabeyaman	Elbe Havel	Gerringong volcanics		Condon Fm	
CISURALIAN	Kungurian	Ufimian	Bolorian		Luodianian	SAKAMOTOZAWAN	Kabayaman		U5b Berry Fm			Degerbols Fm
	Artinskian	LOWER Kungurian	Yahtashian	CHUANSHANIAN	Longlinian				Nowra Ss		Bunbalya Fm	Trold Fiord Fm
	Sakmarian	Artinskian	Sakmarian		Zisongian		Kawaguchian					Amb Fm
	Asselian	Sakmarian	Asselian			WOLFCAMPIAN	Lenoxian		Wandrawandian Siltstone U5a		Mbunedan Fm	
		Asselian					Nealian	Eisenach Fm				Assistance Fm
								Tambach Fm			Coolkilya Ss	
						LEONARDIAN	Cathedralian					
							Hessian	Rotterade Fm	U4 Snapper Point Fm		Byro Gr	Great Bear Cape Fm
											Wooramel Gr	
								Oberhof Fm	L4 Pebbly Beach Fm		Callytharra Fm	Rannes Fm
								Goldlantel Fm			Carrandibby Fm	
									3a-b Allandale Fm			Belcher Channel Fm
								Manebach Fm	Lochinvar Fm		Lions Gr	
											NILAWAHAN GROUP	
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