FUSULINACEAN BIOSTRATIGRAPHY AND CARBONATE PETROGRAPHY OF KHAO KHWANG AND KHAO KHAD FORMATIONS, SARABURI PROVINCE

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การลำดับชั้นหินทางชีวภาพของฟิวซูลินิดและศิลาวรรณนาของหินคาร์บอเนตในหมวดหินเขาขวางและเขาขาด จังหวัดสระบุรี

น.ส.สุธารัตน์ สีรอด

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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Thesis Title	FUSULINACEAN BIOSTRATIGRAPHY AND CARBONATE PETROGRAPHY OF KHAO KHWANG AND KHAO KHAD FORMATIONS, SARABURI PROVINCE
By	Miss Sutharat Sirot
Field of Study	Geology
Thesis Advisor	Associate Professor THASINEE CHAROENTITIRAT, Ph.D.

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สุธารัตน์ สีรอด : การลำดับชั้นหินทางชีวภาพของฟิวซูลินิดและศิลาวรรณนาของหินคาร์บอเนตในหมวดหินเขาขวางและเขาขาด จังหวัดสระบุรี. (FUSULINACEAN BIOSTRATIGRAPHY AND CARBONATE PETROGRAPHY OF KHAO KHWANG AND KHAO KHAD FORMATIONS, SARABURI PROVINCE) อ.ที่ปรึกษาหลัก : รศ. ดร.ฐาสิณีย์ เจริญฐิติรัตน์

การทำวิจัยนี้มีจุดประสงค์เพื่อศึกษาศิลาวรรณนาของหินคาร์บอเนต ชนิดของฟิวซูลินิด และอายุหิน และศึกษาความสัมพันธ์ของหมวดหินเขาขวางและเขาขาด จังหวัดสระบุรี โดยเทียบเคียงจากการลำดับชั้นหินทางชีวภาพของฟิวซูลินิด

จากการศึกษาพบว่าฟิวซูลินิดในพื้นที่ศึกษาจำแนกได้ 5 วงศ์11 วงศ์ย่อย 15 สกุล 15 ชนิด คือ *Robustoschwagerina, Yangchienia, Parafusulina loeyensis, Parafusulina gigantea, Laosella edoensis, Pseudofusulina, Chusenella chihsiaensis, Chusenella* (*Chusenella*) *shengi, Verbeekina verbeeki, Misellina, Pseudodoliolina, Thailandina buravasi, Neoschwagerina megasphaerica, Colania douvillei, Lepidolina shiraiwensis, Presumatrina ciryi, Sumatrina annae* และ *Sumatrina* cf. *longissima* ฟิวซูลินิดเหล่านี้บ่งบอกอายุการสะสมตัว ในหมวดหินเขาขาดอายุการสะสมตัวแก่สุด Sakmarian ถึง Yakhtashian และอายุอ่อนสุด Midian ส่วนในหมวดหินเขาขวางอายุการสะสมตัวแก่สุด Murgabian และอ่อนสุด Midian ผลการศึกษาศิลาวรรณนาสามารถจัดแบ่งหินปูนในพื้นที่ศึกษาออกเป็น calcimudstone, bioclasitic wackestones, bioclastic floatstone, bioclastic packstone, bioclastic rudstone และ microbial boundstone หินคาร์บอเนตเหล่านี้บ่งบอกสภาพแวดล้อมการสะสมตัวของหินมีความหลากหลาย มีการสะสมตัวตั้งแต่ tidal, shelf จนถึง slope deposit

เมื่อเทียบความสัมพันธ์หมวดหินเขาขวางและหมวดหินเขาขาดบ่งบอกว่าหมวดหินเหล่านี้สะสมตัวต่างบริเวณ ต่างพื้นที่ ในช่วงอายุที่คาบเกี่ยวกันอย่างน้อยในช่วง Early Middle Permian ถึง Late Middle Permian (Murgabian ถึง Midian)

สาขาวิชา ธรณีวิทยา ลายมือชื่อนิสิต .....

ปีการศึกษา 2563 ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

6072223123 : MAJOR GEOLOGY

KEYWORD: Fusulinid, Biostratigraphy, Saraburi Group, Carbonate petrography

Sutharat Sirot : FUSULINACEAN BIOSTRATIGRAPHY AND CARBONATE PETROGRAPHY OF KHAO KHWANG AND KHAO KHAD FORMATIONS, SARABURI PROVINCE. Advisor: Assoc. Prof. THASINEE CHAROENTITIRAT, Ph.D.

These research purposes are to study petrography, fusulinids assemblage and age and study biostratigraphy correlation of Khao Khwang and Khao Khad Formations, Saraburi province.

The fusulinids from the study area belong to 5 families, 11 subfamilies, 15 genera and 15 species including *Robustoschwagerina, Yangchienia*, *Parafusulina loeyensis*, *Parafusulina gigantea*, *Laosella edoensis*, *Pseudofusulina*, *Chusenella chihsiaensis*, *Chusenella* (*Chusenella*) *shengi*, *Verbeekina verbeeki*, *Misellina*, *Pseudodoliolina*, *Thailandina buravasi*, *Neoschwagerina megasphaerica*, *Colania douvillei*, *Lepidolina shiraiwensis*, *Presumatrina ciryi*, *Sumatrina annae* and *Sumatrina* cf. *longissima*. These fusulinids indicated that Khao Khad Formation was deposited oldest in Sakmarian to Yakhtashian and youngest in Midian age and Khao Khwang Formation was deposited oldest in Murgabian and youngest in Midian age. The petrographic study indicates that the carbonate rocks of the study area could be classified to calcimudstone, bioclastic wackestones, bioclastic floatstone, bioclastic packstone, bioclastic rudstone and microbial boundstone. The depositional environments of these carbonate rocks were varied from tidal, shelf and slope deposit.

The Khao Khwang and Khao Khad Formations correlation indicated that these formations were deposited in different localities in the same age at least in Early Middle Permian to Late Middle Permian (Murgabian to Midian).

Field of Study:	Geology	Student's Signature .....
Academic Year:	2020	Advisor's Signature .....

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I would like to sincerely thank you to my precious family for unconditionally love and supports. Regardless to my age and what I am doing they always being supportive and encouraging. I am gratefully thank you for everything that allowed me to a part of this lovely family. In additional, thanks to all of my beloved friends for understanding, caring and positive energy that fulfilled and comforted my heart and emotion.

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Sutharat Sirot

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CHAPTER 1
INTRODUCTION

1.1 Rationale

Saraburi Group is the significant Upper Paleozoic rocks of Thailand and widely distributed in Saraburi province and adjacent areas (Figure 1.1). It consists of 6 formations: Phu Phe, Khao Khwang, Nong Pong, Pang Asok, Khao Khad and Sup Bon in ascending order. Total thickness is about 5,000 meters (Hinthong, 1981 and Hinthong et al., 1985).

This research will focus on Khao Khwang and Khao Khad formations that exposed in Saraburi province. They consist mainly of carbonate rocks with abundant fusulinid fauna and they were deposited in shallow marine environments.

Previous studies showed that Khao Khwang and Khao Khad formations have similarity of fusulinid which is determined upper Lower Permian to Middle Permian. Relationship of these formations may not be superposition.

Moreover, Morley et al. (2013) suggested that many thrust faults and complicated structures have been observed in all rock units of the Saraburi Group. It may be too thick or stratigraphic repetition due to thrust faults and complicated structures.

Therefore, Khao Khwang and Khao Khad formations need fusulinacean biostratigraphy to correlate between these two formations due to fusulinid is an index fossil and provides precise age determination and carbonate petrography can indicate paleoenvironments of carbonate rocks.

1.2 Objectives

The carbonate rock and fusuilinid samples were collected from the study area. The purposes of this research are;

1) To study carbonate petrography, fusulinid assemblage and age.

2) To study biostratigraphy in order to know the relationship between the Khao Kwang and Khao Khad formations.

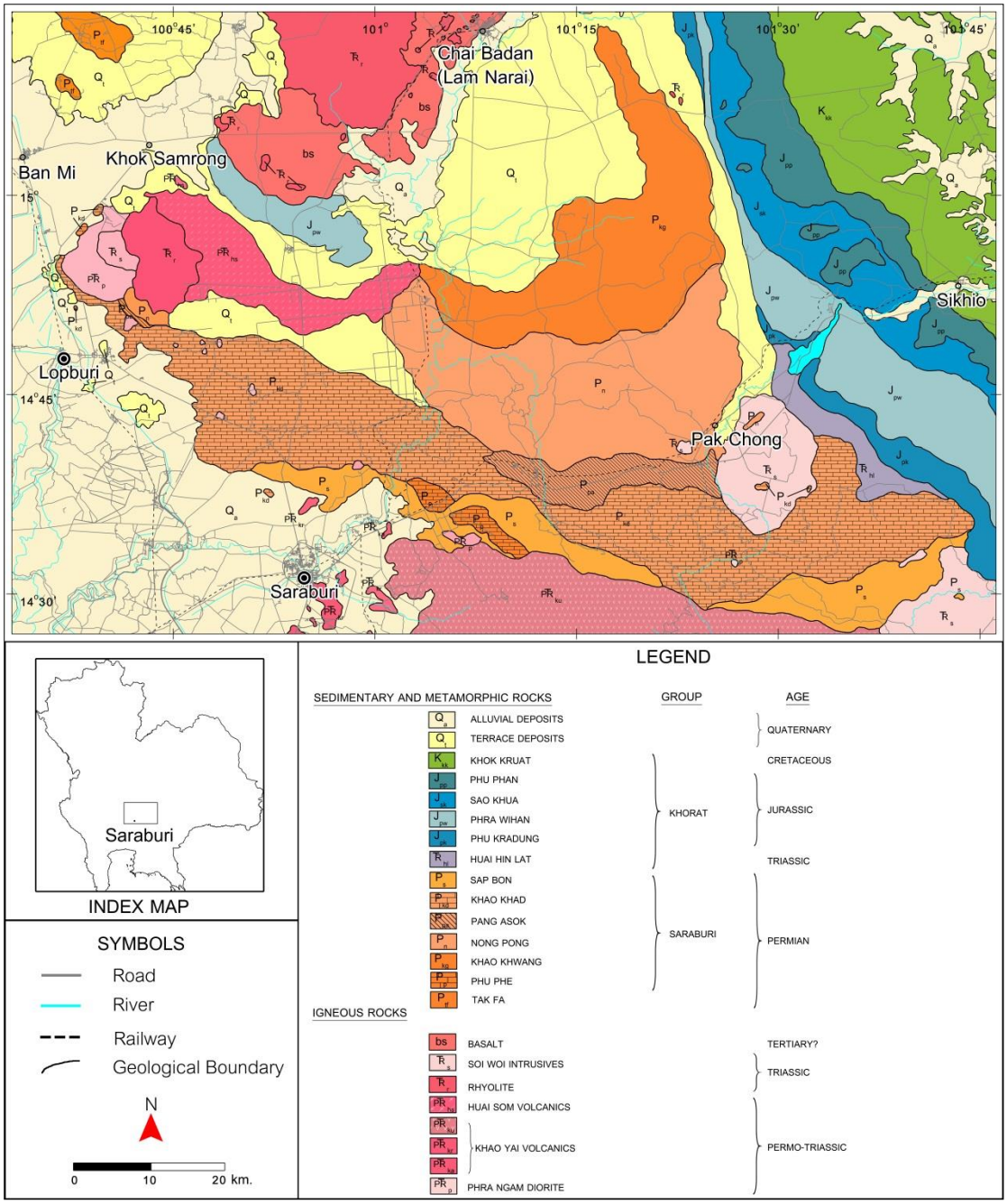

Figure 1.1 Geologic map of Saraburi Group. Study area belongs to Khao Khwang and Khao Khad formations in Saraburi province (modified from Hinthong et al., 1985).

1.3 Methodology

1.3.1 Literature review and preparation

The literature review on the published related geological works and fusulinid in the study area was conducted to provide background knowledge and important data. After that, concluding the issues in the area will be set hypotheses, objectives and the expected result of this research. Then, plan for field works and laboratory studies in the next step.

1.3.2 Field works

Total 43 sample localities were recorded stratigraphy, sedimentary and geology data before collected from the outcrops which focuses on the carbonate rocks and fusulinid samples distribute in Khao Khwang and Khao Khad formations. Collected samples location (Figure 1.2) have both isolated outcrop and measured section.

1.3.3 Laboratory

420 thin sections were prepared for fusulinid identification and carbonate petrography. Fusulinid systematic paleontology is examined whereas carbonate petrography is studied base on the classification of Wright (1992). Depositional environment of these formations will be used data from carbonate petrography. Fusulinid can provide age determination of carbonate rocks and fusulinacean biostratigraphy will be prepared for correlation.

1.3.4 Conclusion and writing report

The fusulinacean biostratigraphy and carbonate petrography of Khao Khwang and Khao Khad formations will be concluded. The report was prepared to accord with the objectives of this research.

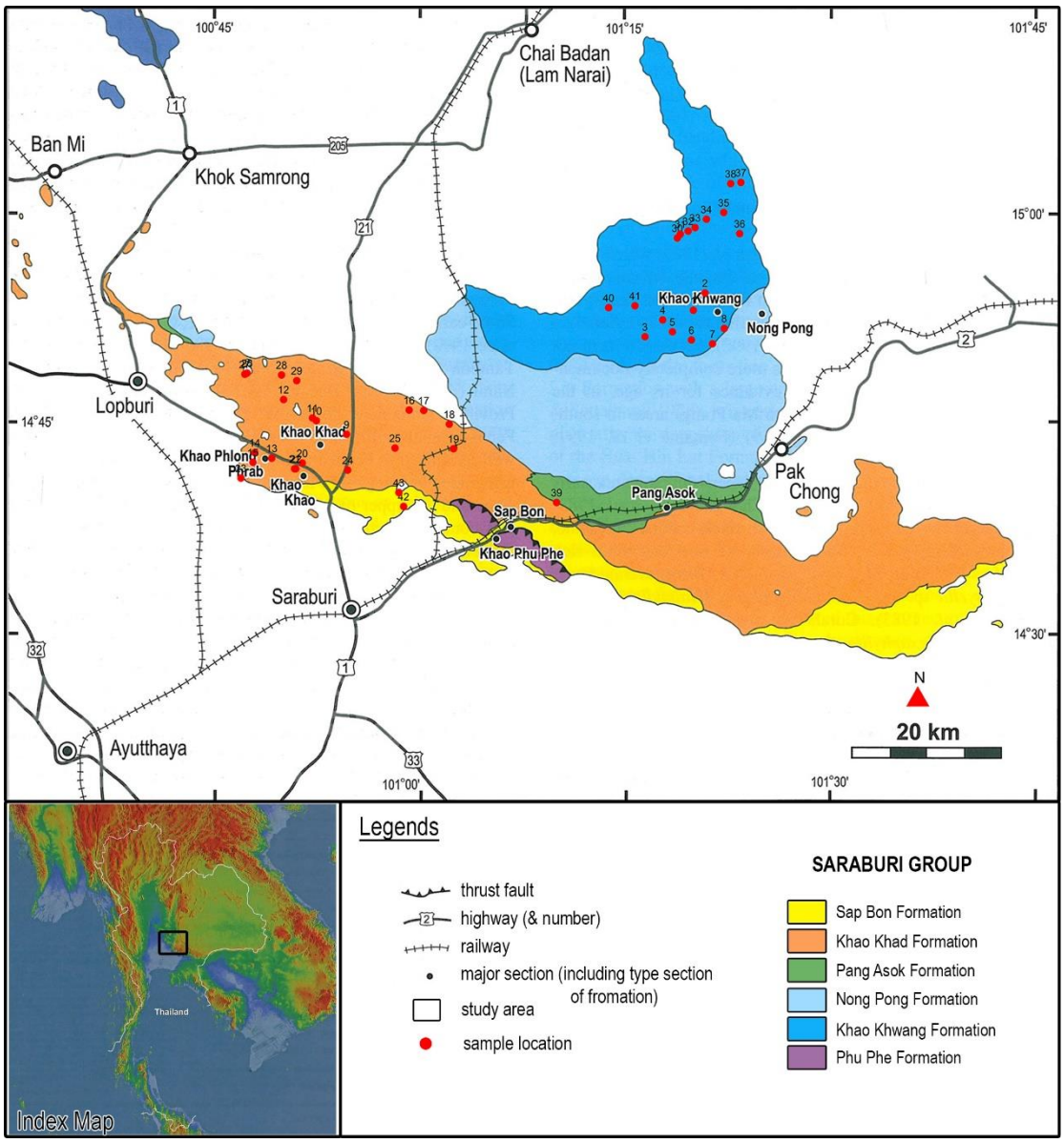

Figure 1.2 Geologic map of Saraburi Group with sampling locations (modified from Ueno and Charoentitirat, 2011).

1.4 Basic knowledges of fusulinid and carbonate petrography

1.4.1 Fusulinids

Fusulinids are single-cell marine organisms in fusulinida order and foraminifera class which normally classified as protozoan phylum. Their wall structures were composed of calcareous layers. Their early life form is a small disk-shaped, planispiralled members. Progressively, their forms expand along the axis of coiling to

fusiform. Some become globular and subspherical shape for floating or planktonic living. Their live-in habitat is the warm shallow marine environment. The resistance of the fusulinids wall can preserve stratigraphic record and depositional environments (Singer, 1999).

Fusulinid identification and classification can be done base on their morphological features and geometry form. The detailed inner structure such as wall structure, septa form, chamber character will be the main to identify and classify fusulinid to families. Fusulinid morphology features and different wall structure (Figure 1.3). Major families of fusulinid contain Ozawainellidae, Schubertellidae, Fusulinidae, Schwagerinidae, Staffellidae, Verbeekinidae and Neoschwagerinidae (Figure 1.4).

Fusulinids are widespread distribution, rapid evolution and short-range age. Their extinction in Late Permian time event. They become index fossil for Carboniferous and Permian. Fusulinids were used widely for the age determination of rocks and depositional environment interpretation. In this study, fusulinid will be used to prepare biostratigraphy correlation and indicate the deposition environment of carbonate rocks.

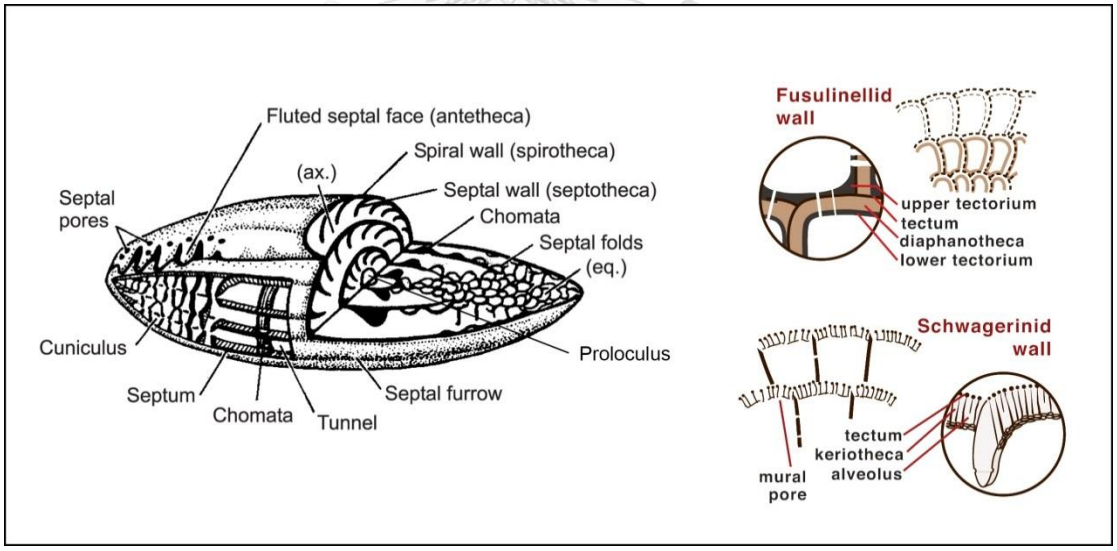

Figure 1.3 Fusulinid morphological features (Armstrong and Brasier, 2005 and Scholle and Ulmer-Scholle, 2003). Morphology and wall structure will be classified and subdivided fusulinid to major family.

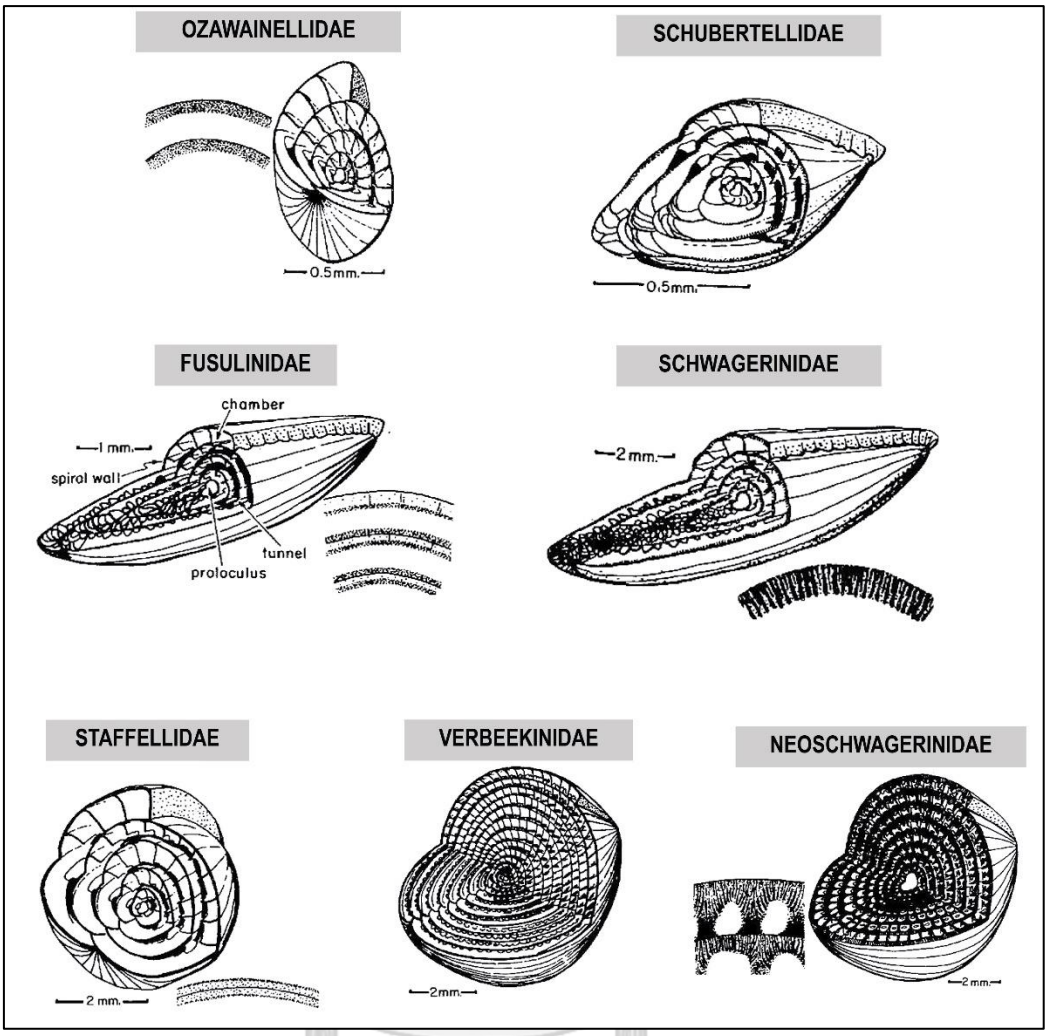

Figure 1.4 Major families of fusulinida with wall structures. The each of major families have distinguish internal morphology and wall structure (Ross et al., 1997).

1.4.2 Carbonate petrography

Carbonate rocks compose mainly of carbonate minerals. The carbonate minerals can be classified into three main groups, calcite, dolomite and aragonite group. Calcite ($CaCO_3$) is the dominant mineral of limestones, especially rocks which older than the Tertiary. Dolomite ($CaMg(CO_3)_2$) is the dominant mineral of dolomites, commonly associated with calcite or evaporite minerals. Aragonite ($CaCO_3$) is only important in Cenozoic carbonate rocks and modern carbonate sediments.

Three major components of limestones are carbonate grains, micrites or microcrystalline carbonates and sparry calcite. Carbonate grains were called grains, particles, constituents and allochem. These carbonate grains are the organic and non-

organic particles of limestones that are larger than the groundmass. Micrites are very fine-grained size carbonate sediment which is distinguished from carbonate grains by finer size. In other words, there is clay-size matrix in clastic rocks. Sparry calcite crystals are larger than micrite and distinguished from carbonate grains. In limestones, sparry calcite occurs as the cement in space of carbonate grains (Boggs, 2009).

In this research will be used revised Dunham classification by Wright (1992) because there is detailed classification and can be used to indicate depositional environments of carbonate rocks in the study area. The revised Dunham classification by Wright (1992) is presented in Figure 1.5.

Microfacies are regarded as the total of all sedimentological and paleontological data which can be described and classified from thin sections, peels, polished slabs or rock samples. The microfacies analysis provided a detailed inventory of carbonate rock characteristics that can subsequently be related to depositional condition (Flügel, 2010).

Table 1.1 Carbonate classification based on Wright (1992).

<table>
<tr><td colspan="4">DEPOSITIONAL</td><td colspan="3">BIOLOGICAL</td><td colspan="3">DIAGENETIC</td><td></td></tr>
<tr><td colspan="2">Mixed supported clay and silt grains)</td><td colspan="2">Grain-supported</td><td colspan="3">In situ organisms</td><td colspan="3">Non-obliterative</td><td>Obliterative</td></tr>
<tr><td>< 10% grains</td><td>> 10% grains grains</td><td>with matrix</td><td>no matrix</td><td>rigid organisms dominant</td><td>encrusting binding organisms</td><td>organisms acted to baffle</td><td>main component in cement</td><td>many grain contacts micro-stylolites</td><td>most grain ascontacts are micro-stylolites</td><td>crystals > 10 μm</td></tr>
<tr><td>CALCI--MUDSTONE</td><td>WACKE--STONE</td><td>PACK--STONE</td><td>GRAIN--STONE</td><td>FRAME--STONE</td><td>BOUND--STONE</td><td>BAFFLE--STONE</td><td>CEMENT--STONE</td><td colspan="2">CONDENSED GRAINSTONE</td><td>FITTED SPARSTONE</td></tr>
<tr><td></td><td>FLOATSTONE</td><td colspan="2">RUDSTONE</td><td colspan="6"></td><td>Crystals < 10 μm MICRO--SPARSTONE</td></tr>
<tr><td></td><td colspan="3">Grains > 2 mm</td><td colspan="6"></td></tr>
</table>

1.5 Previous investigation

Hinthong (1981) and Hinthong et al. (1985) divided Saraburi Group by lithostratigraphy into six formations. Khao Khwang Formation consists of gray to dark gray, fine-grained, thick bedded limestone. Dolomitic limestone, shale and sandstone can be found in some part and often in nodular cherts. Type section located at the cross-section of Khao Khwang hill, Wang Muang, Saraburi. Meanwhile, Khao Khad Formation consists of light gray to dark gray, thick bedded to massive limestone. Argillaceous and dolomitic limestones are in some part. Commonly chert beds interbedded with limestone. Occasionally nodular cherts are found in limestone beds.

Andesite dikes intruded and locally metamorphosed limestone as marble, calc-silicate rocks and hornfels. Type section located at Khao Khad hill along Highway Number 21, Phra Phutthabat, Saraburi. Both formations were deposited in a shallow marine environment. Khao Khwang and Khao Khad formations had similar fossil assemblage and their ages are overlapped. Khao Khwang Formation found lower Permian to lower middle Permian fusulinids while Khao Khad Formation found lower Permian to lower middle Permian fusulinids.

Pitakpaivan (1966) studied fusulinid in Thailand and focused on Nakhonsawan, Phetchabun, Lopburi, Loei and Saraburi limestones to correlation with lower Permian to upper Permian of Tethys region in another area. This work studied at Khao Prong Prap, Phra Phutthabat, Saraburi and adjacent area found important fusulinids such as Neoschwagerina megasphaerica DEPRAT, Sumatrina annae stricta DEPRAT, Verbeekina verbeeki (GEINITZ) forma A and etc. indicated that Upper Permian to Middle Permian age. After that, fusulinid were used as index fossil for Carboniferous to Permian rocks of Thailand.

Toriyama et al. (1974) presented biostratigraphy of Khao Prong Prap which is the first biostratigraphy in this area can be divided into 3 members included Lower A consists of crystalline limestone, Middle B consists of abandon fusulinids and Upper C consists of limestone conglomerate. Fusulinids in Middle B can be also divided into 7 zones included Misellina otai-M. cfr. termieri zone, Misellina confragaspira zone, Maklaya saraburiensis zone, Maklaya pamirica zone, Maklaya sethaputi zone, Neoschwagerina simplex zone and Presumatrina schellwieni zone in ascending order of Middle B indicated that Upper Permian to middle Middle Permian and this biostratigraphy became to standard biostratigraphy of upper Lower Permian to middle Middle Permian for use to correlation with fusulinid from other areas.

Toriyama and Kanmera (1979) studied in biostratigraphy of Khao Khao which located in southeast of Khao Prong Prap and presented 4 biostratigraphic zones included Afghanella megasphaerica-Neoschwagerina cfr. Kueichowensis zone, Afghanella pesuliensis-Pseudodoliolina pseudolepida zone, Afghanella schencki

schencki zone and Neoschwagerina haydeni zone in ascending order indicated that upper Lower Permian to middle Middle Permian age. This biostratigraphic zones can be correlated with previous biostratigraphic zone of Khao Prong Prap area and found that age of lower part of Khao Khao overlapped with the upper part of Khao Prong Prap.

Dawson (1993) and Dawson and Racey (1993) studied in biostratigraphy and carbonate petrography along Highway Number 21, Saraburi to indicate the depositional environment. This work focused facies division included slope-turbidite facies which found fusuline Misellina, Mesoschubertella, Pseudofusulina and etc., the algal reef and transition zone which found fusulines Misellina claudiae, Pseudofusulina vulgaris, Robustoschwagerina and etc., Back reef and patch reef, interior shelf facies which found fusulines Afghanella schencki, Chusenella, Parafusulina kaerimizensis, etc. and protected lagoon & peritidal flats facies which found Psuedodoliolina ozawai, Verbeekgina pontica, Parafusulina gigantea and etc. Moreover, this work found oldest fusulinids which is Lower Permian to Middle Permian.

From previous investigation can conclude that the age of Khao Khwang and Khao Khad formations are overlapped. In other word, the Saraburi Group is not superposition. Therefore, superposition hypothesis of Saraburi Group should be more study.

Moreover, Morley et al. (2013) studied structural geology of Khao Khwang platform (Saraburi Group). The report presented that there are many thrusts in high deformation zones. And stratigraphy separation, fault bend fold and fault propagation fold which are evidences which support that Saraburi Group may be stratigraphic repetition lead to over thickness and bedding orientation is not simple. From this work, it is not easy to divide the Saraburi Group by lithostratigraphy.

1.6 General geology

According to the previously studied Hinthong (1981) and Hinthong et al. (1985), in the study area consist of a group of mixed carbonate-silicicclastic Permian rocks, Saraburi Group and Permo-Triassic igneous rocks. The Saraburi Group was divided to six formations in the Saraburi area included namely the Phu Phe, Khao Khwang, Nong Pong, Pang Asok, Khao Khad and Sup Bon formations and Permo-Triassic igneous

rocks consist of granite, rhyolite and andesite as presented in Figure 1.1. The summarized of geology of the study area are described as follows.

Phu Phe Formation mainly consists of well-bedded gray to dark gray limestones with brownish-gray to dark gray lenticular and nodular chert. In the upper part limestones are frequently massive, while in the lower part light brown to brownish-gray shales and slaty shales are intercalated. The fusuline from Phu Phe Formation included *Triticites, Pseudoschwagerina, Zellia, Acevroschwagerina, Robustoschwagerina* and *Paraschwagerina* (Department of Mineral Resources, 2001 and Hinthong, 1981) which broadly indicate a latest Pennsylvanian – Early Permian (Gzhelian – Yakhtashian) age. The Phu Phe Formation suggests indicated platform carbonate deposition.

Khao Khwang Formation comprises thick bedded, light to dark gray, and occasionally recrystalline limestones, dolomitic limestones and dolomites. Rarely found shales, sandstones, tuffaceous sandstones and volcanic rocks are intercalated in some beds. Some parts are fragments and intercalated with gray to brownish-gray bedded and nodular cherts. Fusulines, brachiopods, bivalves, trilobites, bryozoans and crinoids can be found. Moreover, the Alatoconchidae, a unique Permian giant bivalve also can be found in limestones. The discovered fossil and lithofacies suggested that the formation was deposited in a shallow-marine platform environment.

Nong Pong Formation comprises mainly interbedded shales and limestones. Occasionally the limestones are lenses and lenticular beds especially in the upper part. Shales are mostly brownish-gray grayish-brown to light gray, and bluish-gray, occasionally silty and sandy or siliceous. Limestones are medium gray to dark gray; bedded, banded to well-laminated and argillaceous in some beds. Bedded cherts are generally intercalated in the upper part of the section. Sedimentary facies and depositional environments suggest that it was deposited in a basinal setting (Pendexter, 1980)

Pang Asok Formation mostly consists of gray, bluish-gray, light brown to pale reddish-brown shales, slaty shales, and some slates with lenticular beds of greenish-

gray arkosic sandstones and light gray limestones. Locally, the hornfelses are partially associated. This formation represents marginal-marine siliciclastic facies.

Khao Khad Formation is predominantly composed of thick bedded to massive, medium to dark gray and occasionally recrystalline limestones and dolomites. Generally, gray to brownish-gray bedded and nodular cherts are usually intercalated. However, the interbedded light brown to yellowish-brown cherts sandy, shales, siltstones and sandstones are less abundant. Locally, the rocks are marbles, calc-silicates and hornfelses. There are many studies reported of this formation which made clear by biostratigraphy that Khao Khad Formation range are between Early to Middle Permian. The largely bioclastic limestone lithology indicated shallow-marine deposition in a carbonate-platform environment.

Sap Bon Formation comprises predominantly grayish-brown, brownish-gray, bluish-gray, pale brown, yellowish-brown to buff shales, siliceous shales siltstones, and sandstones. At various horizons gray to dark gray well-bedded limestones, bedded and nodular gray cherts are intercalated. Siliciclastic rocks are partly affected by contact metamorphism and altered into slate, phyllite and schist. The fusulines *Pseudofusulina* sp., *Colonia* cf. *douvillei* and *Neoschwagerina* cf. *margaritae* and the ammonoid *Agathiceras* sp. were found and suggested a younger Middle Permian age.

CHAPTER 2
RESULT

Carbonate rocks of Saraburi Group consist of limestone, dolomitic limestone and dolomite. Fusulinids, coral, crinoid, bivalves, and etc. can be found in these carbonate rocks. The 43 samples were collected from isolated outcrops and measured sections. Sample number will be named as SBR 1 to SBR 43 and SBR stands for Saraburi. Thin section were prepared for classification of fusulinids and carbonate petrography in order to determine age and depositional environments. The descriptions of localities and petrography are presented as follows: -

2.1 Petrographic classification of carbonate rocks and fusulinacean assemblage

Khao Khwang Formation

Khao Khwang Formation distributes at north-east of Saraburi downtown. Samples location of Khao Khwang Formation show in Figure 1.2. 18 sample localities were descripted as follows: -

SBR 1

This sample was collected near small hill behind Wat Nong Iao Nai. It consists of light gray to medium gray, thick bedded to massive limestone. Limestone contains crinoid fragments, coral fragments and algae. Microscopically, bioclastic packstone consists of algae, smaller foraminifera, coral and crinoid fragments in sparry calcite cement (Figure 2.1). Fusulinid was not observed in this area.

SBR 2

The sample locality is a cliff of limestone in Ban Nong Din Daeng Phattana. It is dark gray, thick bedded to massive limestone with black nodular cherts. Bedding plane strike is WSW-ENE and dipping SE. In field, fusulinids and coral can be observed. Limestone outcrop with chert beds is shown in Figure 2.2. The rock is composed bioclastic rudstone. Bioclasts consist of fusulinids (*Colania douvillei, Chusenella, Lepidolina shiraiwensis* and *Sumatrina*) together with smaller foraminifers, peloids, algae, sponges and brachiopod fragments and sparry calcite cement. The fractures were filled with calcite. Photomicrographs of SBR 2 are showed in Figure 2.3.

SBR 3

The outcrop exposed at Wat Sap Haeng Sap Sombun. It consists of limestone interbedded shale (Figure 2.4). Stratigraphic column of SBR 3 is presented in Figure 2.7. Lower part (0-4 m) consists of argillaceous limestone and limestone interbedded with calcareous shale. Middle part (4-7 m) consists of thin bedded of laminated limestone and fossiliferous limestone interbedded with shale. Upper part (7-14.5 m) consists of thin beds limestone interbedded with shale. Bedding orientation is E-W and dipping to S. The rocks are composed bioclastic packstone and bioclastic rudstone with fusulinids (*Verbeekina verbeeki, Yangchienia, Colania douvillei, Parafusulina,* and *Lepidolina shiraiwensis*) algae, smaller foraminifers and brachiopod fragments together with sparry calcite and calcite filled in fractures. Calcimudstone, it consists of only carbonate mud. Photomicrograph of SBR 3 is showed in Figure 2.5 and Figure 2.6.

SBR 4

The location of sample is a hill in Sam Roi Yot Monastery. It consists of white metamorphosed limestone with fusulinids and ostracods. Photograph of metamorphosed limestones is showed in Figure 2.8. Microscopically, the rock is calcimudstone with fusulinids (*Yangchienia*) smaller foraminifers and algae fragments surrounded by micrite. Orientation texture were observed and showed in Figure 2.9.

SBR 5

This sample located at a hill in Wat Kiri Wan. Metamorphosed limestone contains abundant of crinoids and fusulinids. The rock is bioclastic rudstone with fusulinids (*Pseudofusulina* and *Misellina*) smaller foraminifers, algae fragments, bryozoans, crinoids, brachiopod fragments and ostracod and sparry calcite cement.

SBR 6

The outcrop exposed beside road in Khao Khwang Formation. It consists of dark gray to light gray, medium to thick bedded limestone with E-W strike and dipping S. Fusulinids, ammonite and crinoid were be observed. Rock is bioclastic packstone with fusulinids (*Colania douvillei*) and sparry calcite cement.

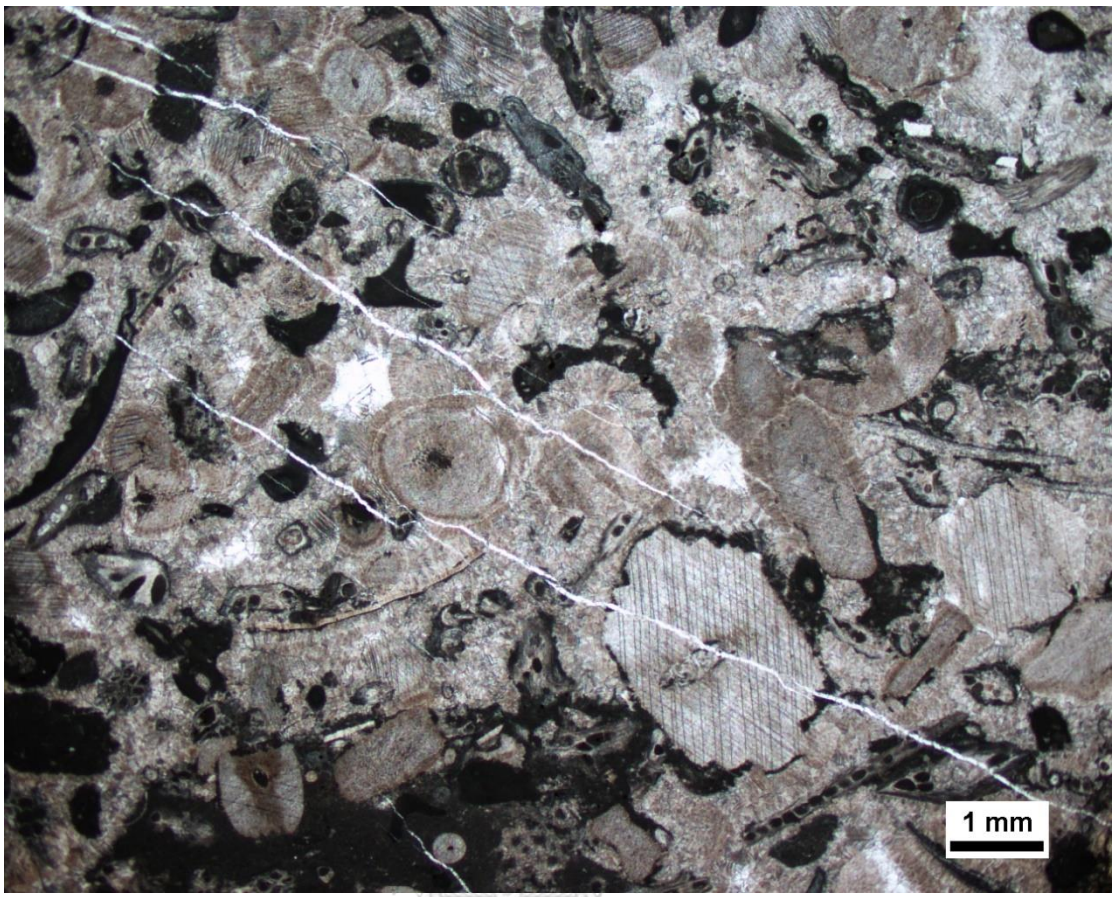

Figure 2.1 Photomicrograph of SBR 1 shows bioclastic packstone with crinoid grains and sparry calcite cement.

Figure 2.2 Outcrop photo of SBR 2. Common limestone of Saraburi Group shows limestone with chert beds.

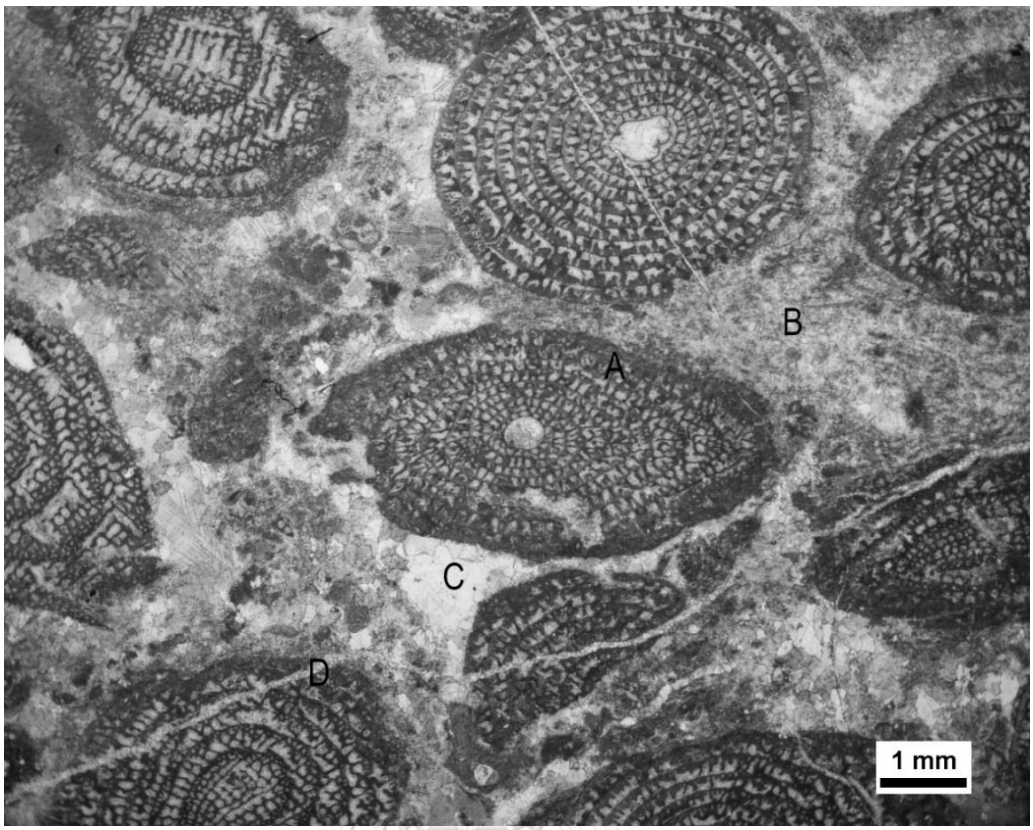

Figure 2.3 Photomicrograph of SBR 2 shows bioclastic rudstone with A) fusulinids (*Colania douvillei*) B) micrite C) sparry calcite cement and D) calcite filled in fractures.

Figure 2.4 Outcrop at SBR 3 shows limestone interbedded with fine grained clastic rock. These rocks can be observed in some part of Saraburi Group.

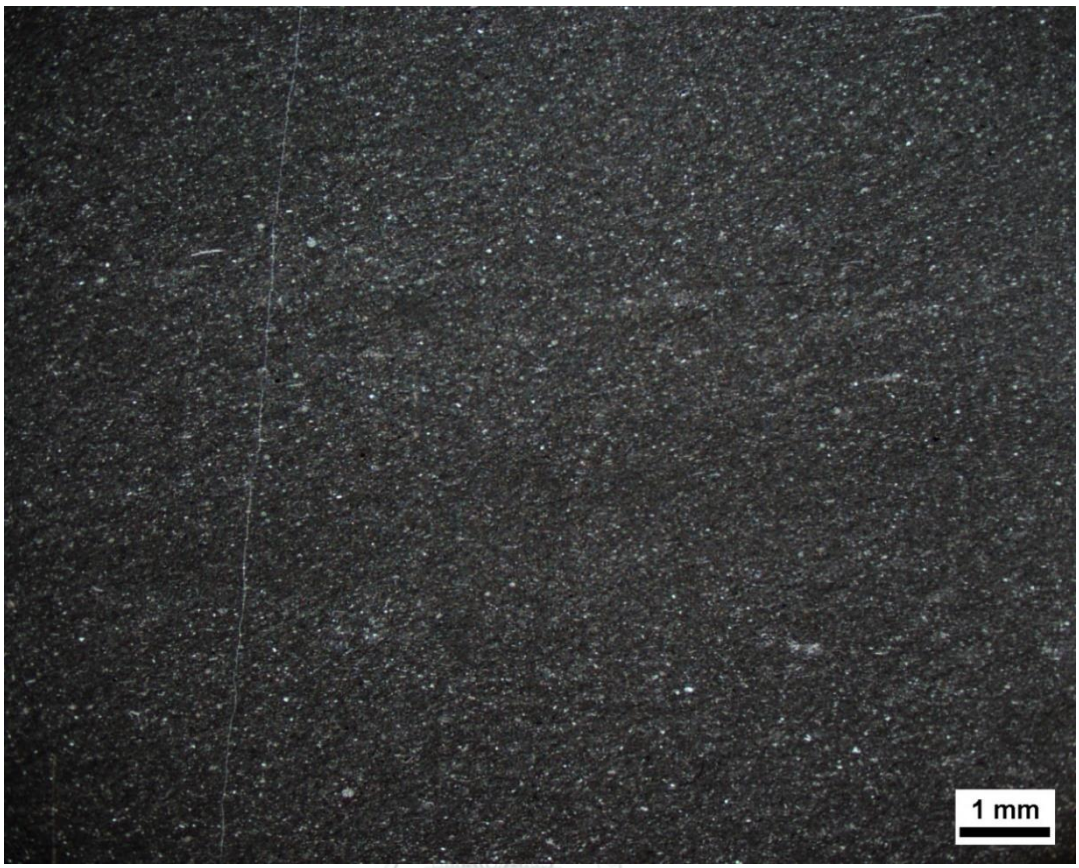

Figure 2.5 Photomicrograph of SBR 3 shows calcimudstone consists of micrite.

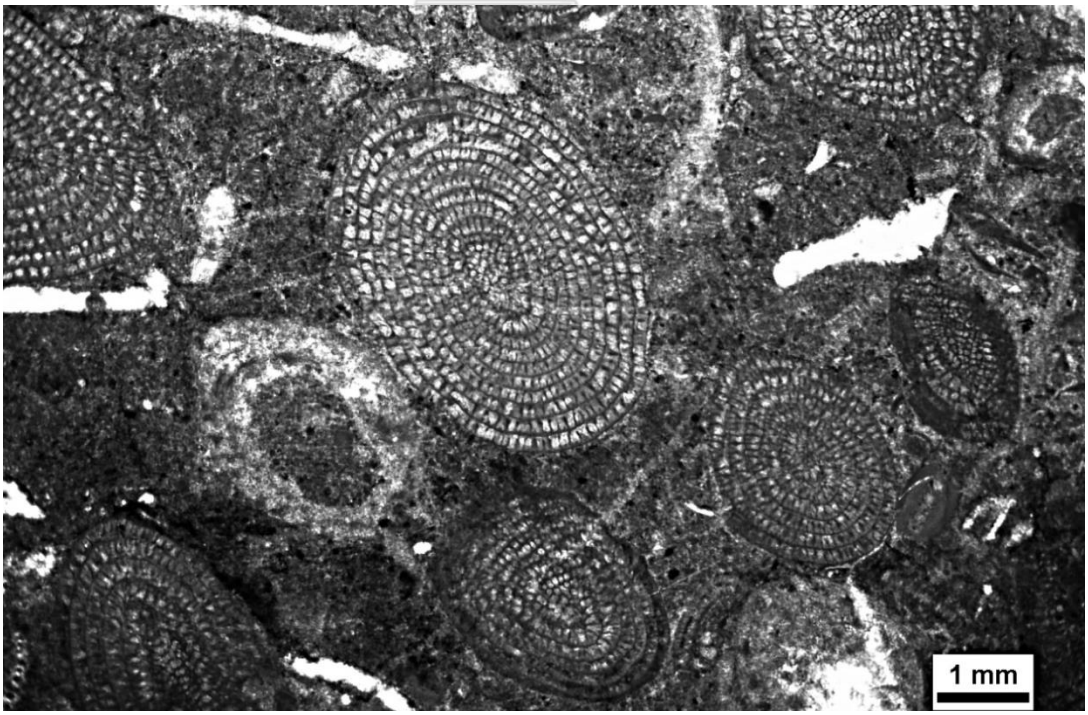

Figure 2.6 Photomicrograph of SBR 3 shows bioclastic rudstone consists of fusulinids, algae and sparry calcite cement.

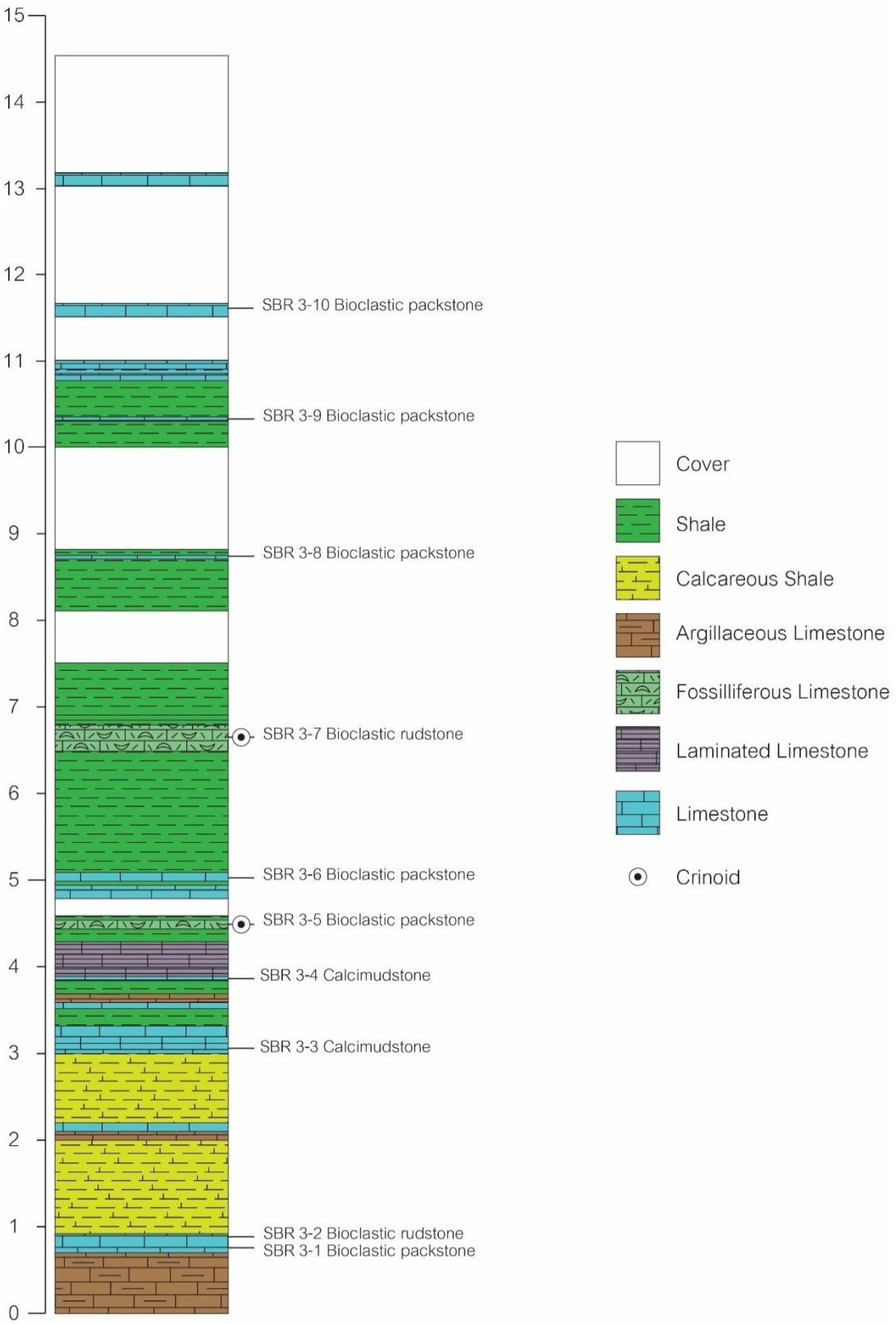

Figure 2.7 Stratigraphic column of SBR 3 shows limestone interbedded with fine grained clastic rocks.

Figure 2.8 Metamorphosed limestone of SBR 4 shows recrystallized texture.

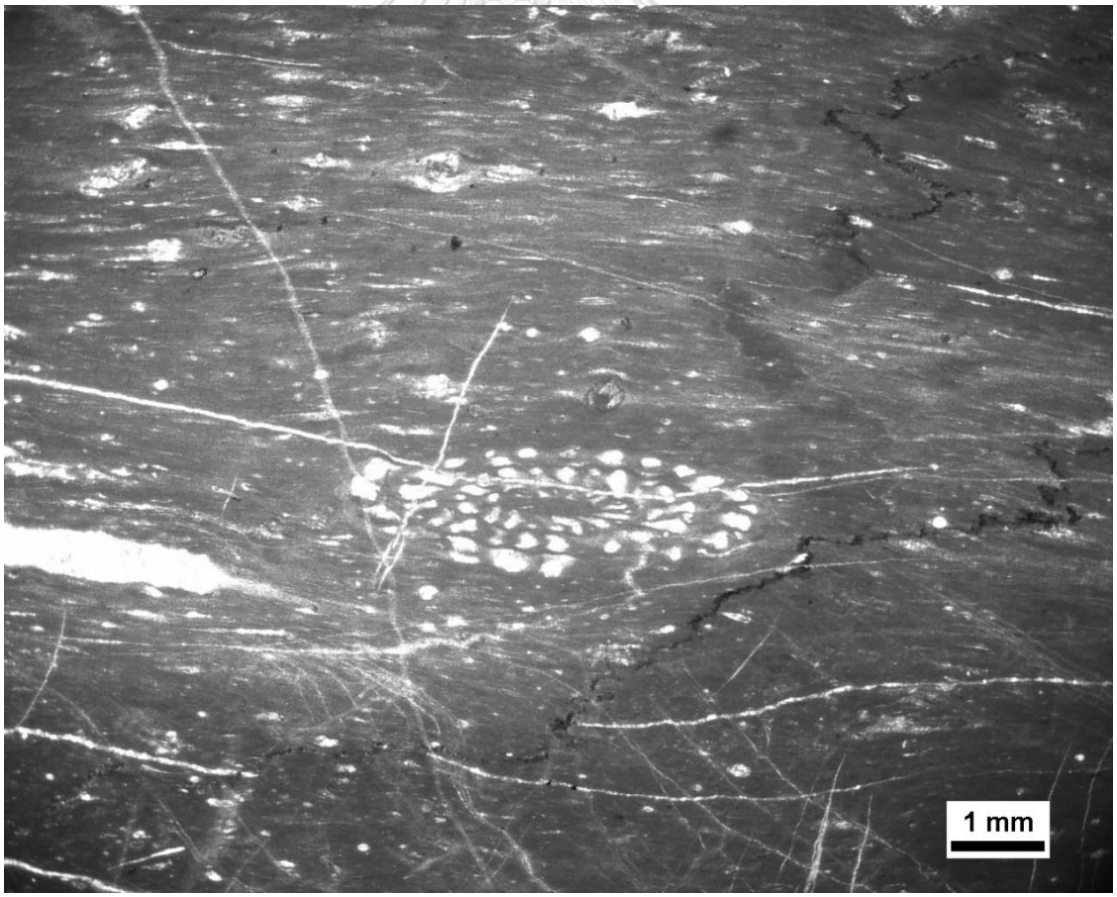

Figure 2.9 Photomicrograph of SBR 4 shows metamorphosed limestone with fusulinid surrounded by micrite.

SBR 7

The outcrop exposed beside road on widely mound in Khao Khwang Formation. It consists of dark gray limestone with black nodular cherts. Limestone contains crinoid, coral, fusulinids and some shell fragments. Rock is composed bioclastic rudstone with fusulinids (*Pseudofusulina* and *Yangchienia*), algae, fragments smaller foraminifers, crinoids and brachiopod fragments. Photomicrograph of SBR 7 shown in Figure 2.10.

SBR 30

The location of sample is small hill behind Tham Khao Wong Songkrot Monastery. It is dark grey to grey limestone with nodular chert. fusulinids and burrows were observed. In microscope, bioclastic rudstone contains with fusulinids (*Parafusulina gigantea* and *Parafusulina loeyensis*) and some calcite filled fractures.

SBR 31

This sample was collected on plain at corn field in Khao Khwang Formation. It consists of grey limestone with black nodular chert. Fossils consist of fusulinids, giant bivalves (Alatoconchidae), ammonite, brachiopod, gastropod and coral. Giant bivalves and coral in limestone with chert is showed in Figure 2.11. In thin section, bioclastic rudstone contains fusulinids (*Colania douvillei* and *Verbeekina verbeeki*), gastropods and giant bivalves fragments and recrystallized in some part. Photomicrograph of SBR 31 is shown in Figure 2.12.

SBR 32

The rock exposed at roadside hill near Ban Pong Sanuan. It is white of recrystallized limestone with loose block of rhyolite. Fossils are algae, ostracod and gastropod. Microscopically, recrystallized bioclastic packstone consists of smaller foraminifers, microbial algae with recrystallized micrite.

SBR 33

The sample located at roadside near Pong Sanuan Monastery. It is light grey to dark grey, thin- to massive bedded limestone. Fusulinids, giant bivalves, gastropod and oncoid were observed. Stratigraphic column is presented in Figure 2.13. Lower part consists of medium to thick beds of limestone with bioclasts. Middle part consists of thick bed limestones with bioclasts. Upper part consists of thick to massive bed

limestones with bioclasts. In thin section, it consists of microbial bounstone, bioclastic packestone and bioclastic wackestone. Grains are fusulinids (*Colania douvillei*), gastropods, smaller foraminifers and microbial surrounded by micrite and sparry calcite cement.

SBR 34

Th location of sample is NE of SBR 33. It is dolomite interbedded with limestone. The fossils consist of smaller foraminifera, giant bivalves. In microscopy, bioclastic rudstone with fusulinids (*Sumatrina annae*).

SBR 35

This sample was collected at foothill in Ban Nong Chang Luen. It consists of dolomite and grey to dark grey limestone with fusulinds. Dolomite and limestone are presented in Figure 2.14. In thin section, bioclastic packestone contains fusulinids, smaller foraminifers and algae with sparry calcite.

SBR 36

The sample locality is roadside outcrop near Khao Chong Lom Monastery. It is dark grey to black limestone with crinoids. Microscopically, it is bioclastic packstone with crinoid fragment together with microbial algae and sparry calcite.

SBR 37

The rock exposed at foothill of Khao Sap Kaeng Kai. It is dolomite and limestone with crinoid. In microscopy, this sample is dolomite and fossils were not observed.

SBR 38

The sample located is W of SBR 37. It is grey to light grey limestone. Fossils consist of fusulinids, coral and gastropods. Microscopically, bioclastic rudstone contains fusulinids (*Lepidolina shiraiwensis, Colania douvillei* and *Pseudodoliolina*) and coral fragments and surrounded by micrite with sparry calcite cement is shown in Figure 2.15.

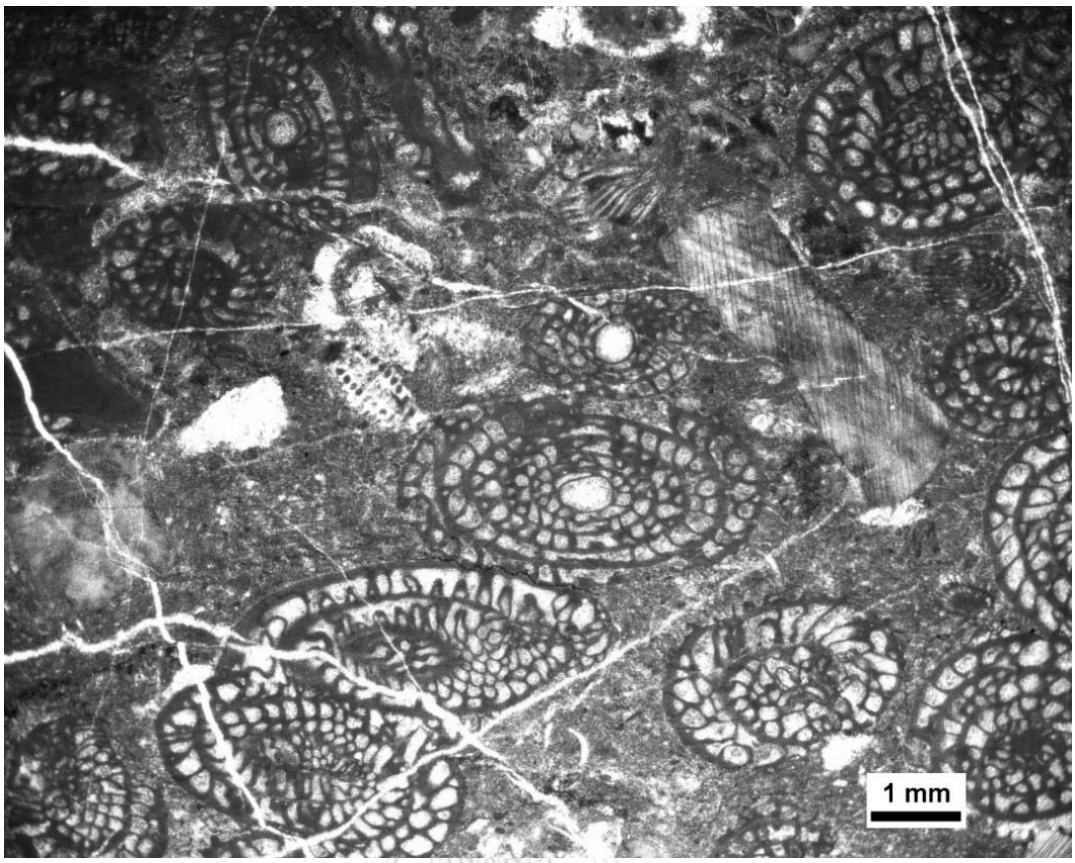

Figure 2.10 Photomicrograph of SBR 7 shows bioclastic rudstone with a lot of fusulinids.

Figure 2.11 Outcrop at SBR 31 shows limestone with chert and giant bivalve (Alatoconchidae) and coral.

SBR 40

This sample was collected at Khao Pha Lat. It is light grey limestone with a lot of fusulinids and algae. In microscopy, it is bioclastic rudstone with fusulinids, smaller foraminifers and small fragments.

SBR 41

This sample locality is east of Khao Pha Lat. It is metamorphosed limestone. In thin section, it presents augen in metamorphosed limestone (Figure 2.16). Fossils were not observed in this location.

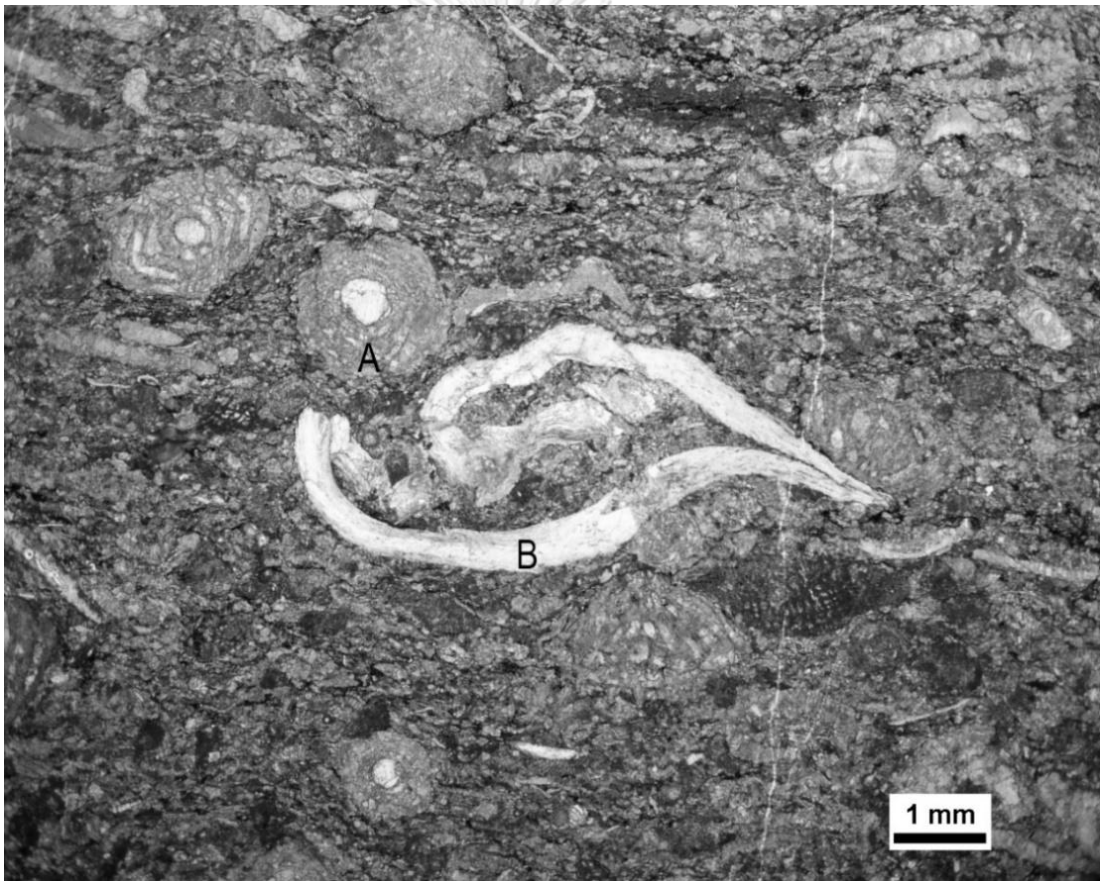

Figure 2.12 Photomicrograph of SBR 31 showing bioclastic rudstone with A) fusulinids and B) Alatoconchidae fragment.

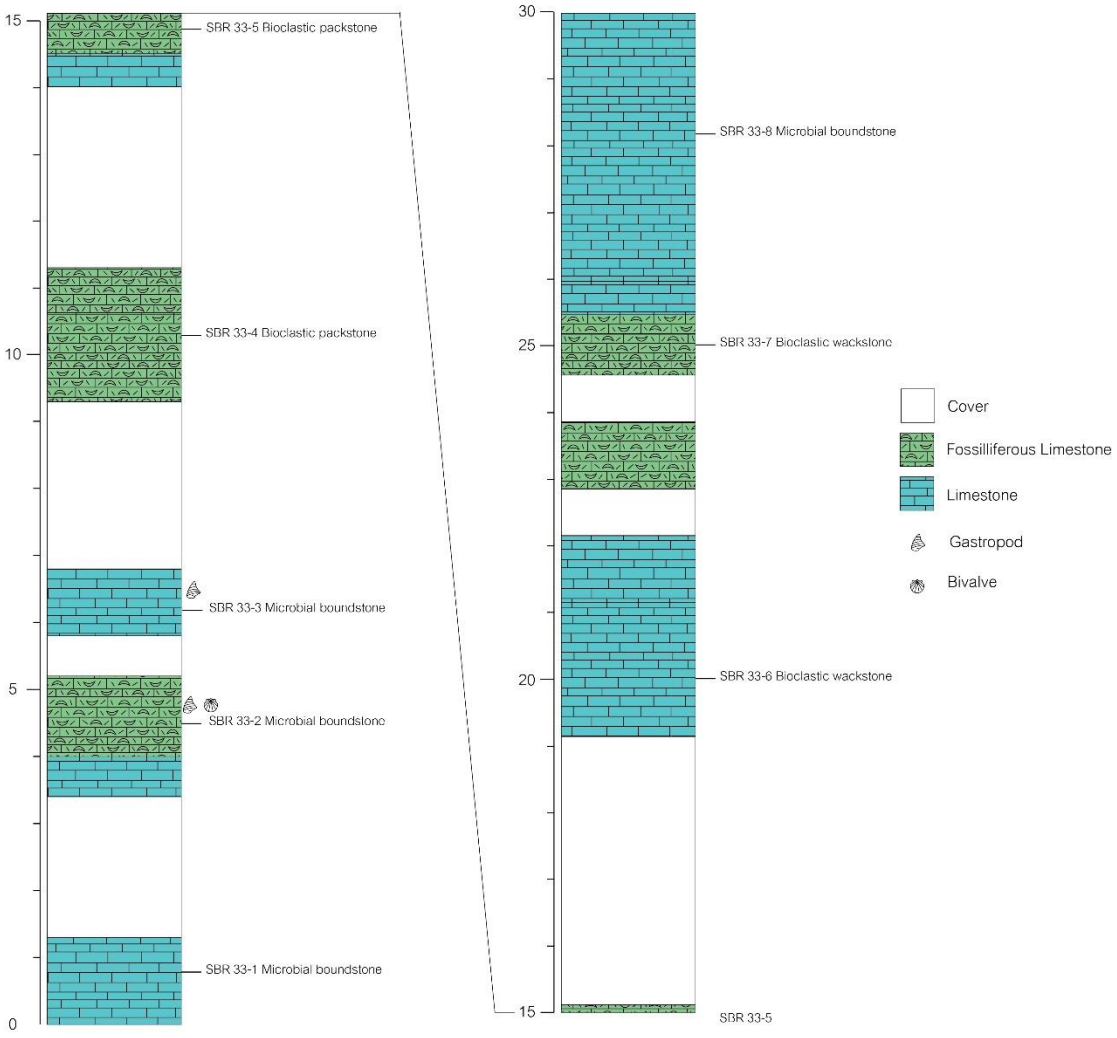

Figure 2.13 Stratigraphic column of SBR 33 consists of thin bedded to thick bedded limestone.

Figure 2.14 Outcrop at SBR 35 shows contact of dolomite and limestone.

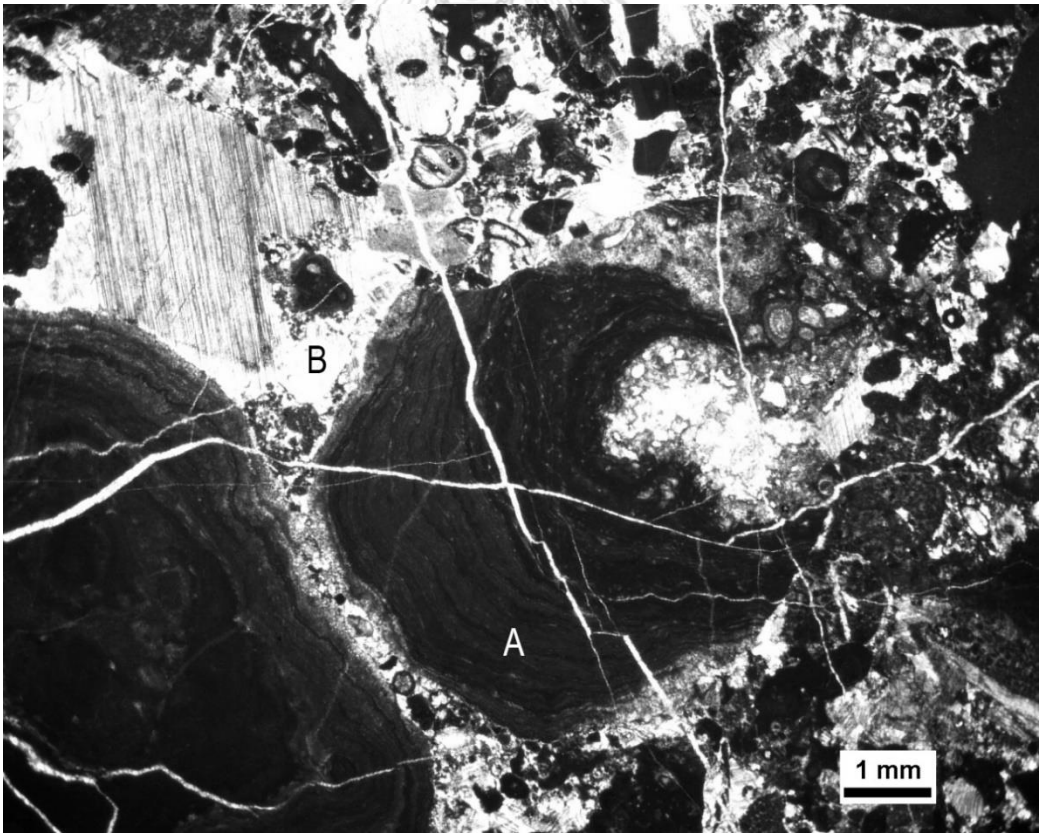

Figure 2.15 Photomicrograph of SBR 38 shows bioclastic rudstone consists of A) algae and B) calcite cement.

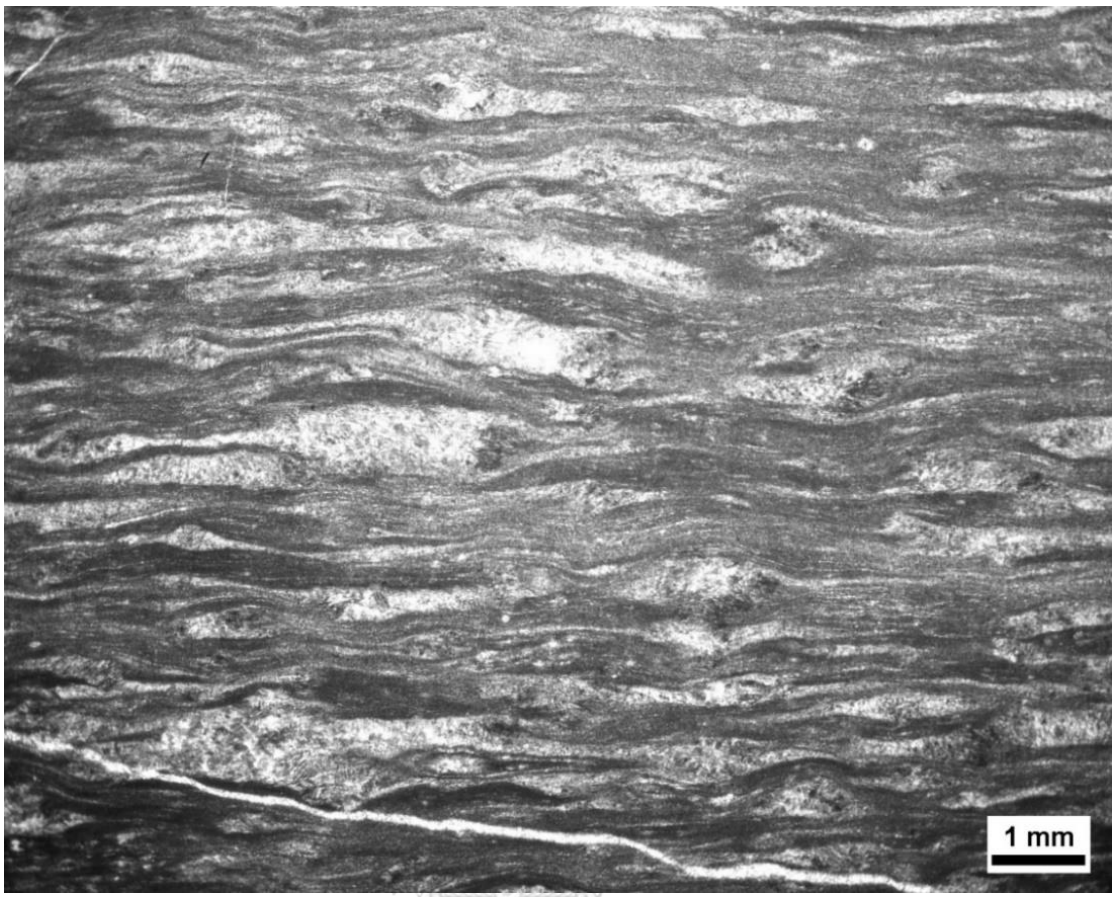

Figure 2.16 Photomicrograph of SBR 41 shows augen in metamorphosed limestone.

Khao Khad Formation

Khao Khad Formation distributes near Saraburi downtown in SW-NE direction. Sample location were presented in Figure 1.2. 24 samples were descripted as follows: -

SBR 9

The sample was collected at Wat Bencha Kiri Nakhon. It is dark gray, massive limestone. Massive limestone is shown in Figure 2.17. In microscopy, Bioclastic rudstone consists of fusulinids (*Verbeekina verbeeki* and *Colania douvillei*) with smaller foraminifers, algae (*Mizzia* sp.?) and ostracods.

SBR 10

The location of sample is small hill near Wat Bo Wong Kru Phattana. It consists of dark to light grey, medium to thick bedded limestone with black nodular cherts. Microscopically, bioclastic rudstone contains a lot of fusulinids (*Colania douvillei, Verbeekina verbeeki* and *Lepidolina shiraiwensis*) crinoid fragments, coral, smaller

foraminifers and brachiopod fragments and sparry calcite. Photomicrograph of SBR 10 is showed in Figure 2.18.

SBR 11

The sample locality is old pit near Wat Bo Wong Kru Phattana. Dark gray metamorphosed limestone interbedded with yellowish brown shale and nodular chert. In microscopy, Bioclastic rudstone consists of fusulinids (*Colania douvillei, Verbeekina verbeeki* and *Lepidolina shiraiwensis*) smaller foraminifers, algae, bryozoans, brachiopod fragments and trilobite fragments.

SBR 12

The rock exposed at Khao Phu Kham near Wat Phu Kham Wan Phloi Charoen. It consists of dark to light grey limestone with nodular cherts. Limestone contains fusulinids and coral. It is bioclastic rudstone, consist of fusulinids (*Sumatrina annae, Sumatrina* cf. *longissima, Verbeekina verbeeki, Chusenella* and *Lepidolina shiraiwensis*) smaller foraminifers, abundant of algae fragments and bryozoans fragments.

Figure 2.17 Limestone at SBR 9 shows massive limestone.

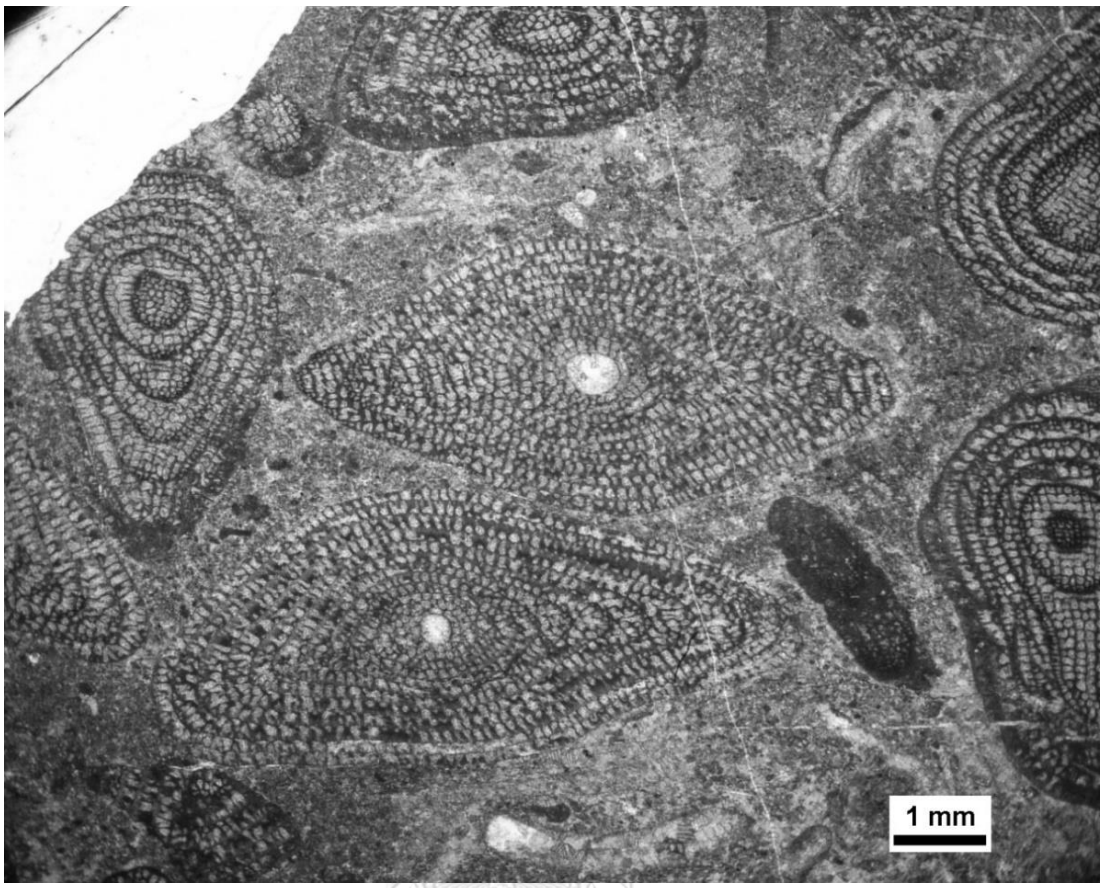

Figure 2.18 Photomicrograph of SBR 10 shows bioclastic rudstone with fusulinids.

SBR 13

This location of sample is a part of Khao Prong Prap. It consists of light grey limestone and metamorphosed limestone. Limestone grains (2-3 cm) and oncoids were found. Bedding plane strike is SSE-NNW and dipping to S. Fossils consist of fusulinids and coral. In microscopy, bioclastic rudstone consist of fusulinids (*Sumatrina, Colania douvillei* and *Neoschwagerina megasphaerica*) smaller foraminifers, algae, brachiopod fragments crinoids fragments, bryozoans, oncoids, pelloids, ooids, and sparry calcite.

SBR 15

This sample was collected at Khao Tham Prathun. It consists of dark grey to light grey limestone with loose block of andesite. Fossil consists of fusulinid and coral. Microscopically, bioclastic rudstone contains fusulinids (*Verbeekina verbeeki, Parafusulina gigantea* and *Colania douvillei*) smaller foraminifers, algae, peloids and brachiopod fragments and sparry calcite.

SRB 16

The sample locality is a part of Khao Khiao. It consists of light grey, coarse to fine grained, medium to thick-bedded limestone with oncoids. Fossils consist of fusulinids and ammonite. In microscopy, microbial boundstone, consists of microbial, algae, smaller foraminifers, fusulinids and brachiopod fragments. Photomicrograph of SBR 16 is shown in Figure 2.19.

SBR 17

This location of sample is east of SBR 16. It consists of dark grey limestone with a lot of fractures and nodular chert. Fusulinids and crinoids were found. In microscope, it is microbial boundstone, consists of a lot of microbial and algae.

SBR 18

The outcrop exposed on roadside near Wat Thum Yanna Sangworn. It is interbedded of dark gray to light gray, laminated to thick bedded limestone. Stratigraphic column is presented in Figure 2.20. Lower part (0-5.5 m) consists of medium to thick beds limestone contain bioclast, bivalves. Upper part (7-12.5m) consists of thick to massive bed limestone contain gastropod in some bed. Fossil consists of fusulinids, ostracods, gastropods and giant bivalves. In microscope, bioclastic packstone, bioclastic floatstone, boundstone and bioclastic rudstone contain fusulinids (*Colania douvillei*), a lot of smaller foraminifers, algae and brachiopod fragments.

SRB 19

The sample was collected from roadside small hill a part of Khao Hin Dat. It consists of dark grey limestone with calcite veins. Limestone contains fusulinids. In microscope, it is bioclastic rudstone, consists of fusulinids (*Verbeekina verbeeki, Yangchienia Pseudofusulina* and *Presumatrina*) smaller foraminifers, ostracod fragments and algae.

SRB 20

The rock exposed at foothill near Sila Sanon quarry. Limestone contains a lot of fusulinids and calcite veins. Microscopically, it consists of bioclastic rudstone and

boundstone, bioclasts are composed of fusulinids (*Sumatrina, Colania douvillei, Verbeekina verbeeki* and *Parafusulina*) algae, smaller foraminifers and intraclasts.

SBR 21

The sample locality is small hill near Wat Sap Cha-Om. It is light grey limestone with fusulinids and calcite veins. In microscope, bioclastic rudstone consists of fusulinids (*Sumatrina* and *Colania douvillei*), algae and intraclasts.

SBR 22

The sample located west of SBR 21. It is light grey, coarse to fine grained limestone with fusulinids. Microscopically, bioclastic rudstone consists of fusulinids (*Thailandina buravasi* and *Chusenella* (*Chusenella*) *shengi, Pseudofusulina* and *Parafusulina gigantea*) smaller foramnifers, algae, brachiopod and gastropod fragments and peloids.

SBR 23

The rock exposed at foothill near Wat Khao Noi. Limestone contains a lot of calcite vein and fusulinids. In microscope, bioclastic wackestone consists of fusulinid (*Colania douvillei*) algae, brachiopod fragments and intraclasts.

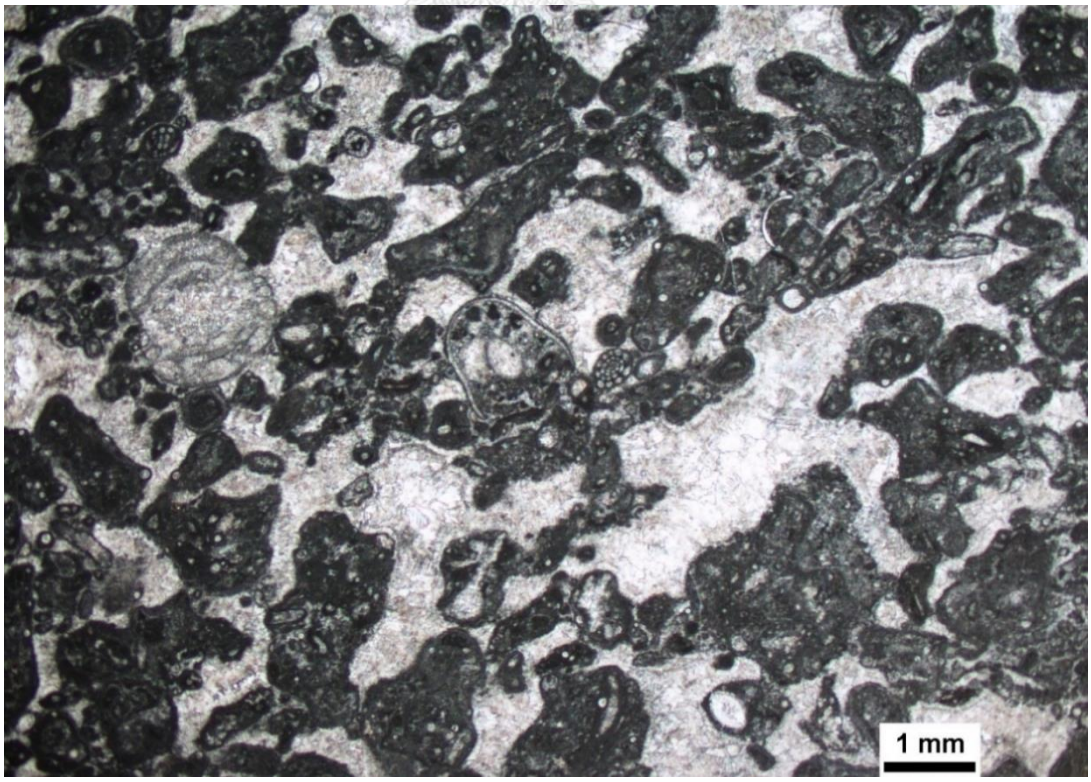

Figure 2.19 Photomicrograph of SBR 16 shows algae and microbial with calcite cement.

SBR 24

The outcrop exposed at a foothill near Wat Tham Phothiyan. It consists of white to light grey recrystalline limestone with a lot of fusulinids and crinoids. In microscope, boundstone, consists of fusulinids (*Colania douvillei*), algae and intraclasts.

SBR 25

The rock exposed at foothill of Khao Khrao. Grey, thick-bedded limestone contains a lot of fusulinids, crinoid, coral and shell fragments. In thin section, bioclastic rudstone consists of fusulinids (*Presumatrina ciryi*, *Colania douvillei* and *Verbeekina verbeeki*) smaller foraminifers, microbial algae, crinoid fragments, coral fragments and sparry calcite cement.

SBR 26

The location of sample is foothill of Khao Nong Muang. It consists of black metamorphosed limestone with white volcanic rocks. In microscopy, it is recrystallized limestone and fossil was not observed in this location.

SBR 27

The sample locality is SW of SBR 26. It is dark grey metamorphosed limestone with nodular chert. Cavity deposits texture was be observed. In microscope, it is recrystallized texture and microphotograph of SBR 27 is showed in Figure 2.21.

SBR 28

The outcrop exposed at foothill near Wat Tham Phra That. It is light grey to medium grey limestone with a lot of fusulinids, coral and calcite veins. Limestone with a lot of fusulinids is presented in Figure 2.22. Microscopically, bioclastic rudstone and bioclastic floatstone with fusulinids (*Laosella edoensis*, *Parafusulina loeyensis*, *Parafusulina gigantea*, *Pseudofusulina*, *Chusenella,* and *Sumatrina annae*) algae, smaller foraminifers and shell fragments.

SBR 29

The sample located at foothill of Khao Kong Bandai of Khao Khad Formation zone. It is dark grey to grey limestone with black nodular cherts and a lot of fusulinids. In thin section, bioclastic rudstone contains fusulinids (*Colania douvillei*, *Sumatrina annae* and *Parafusulina*), smaller foraminifers and a lot of fractures shown in Figure 2.23.

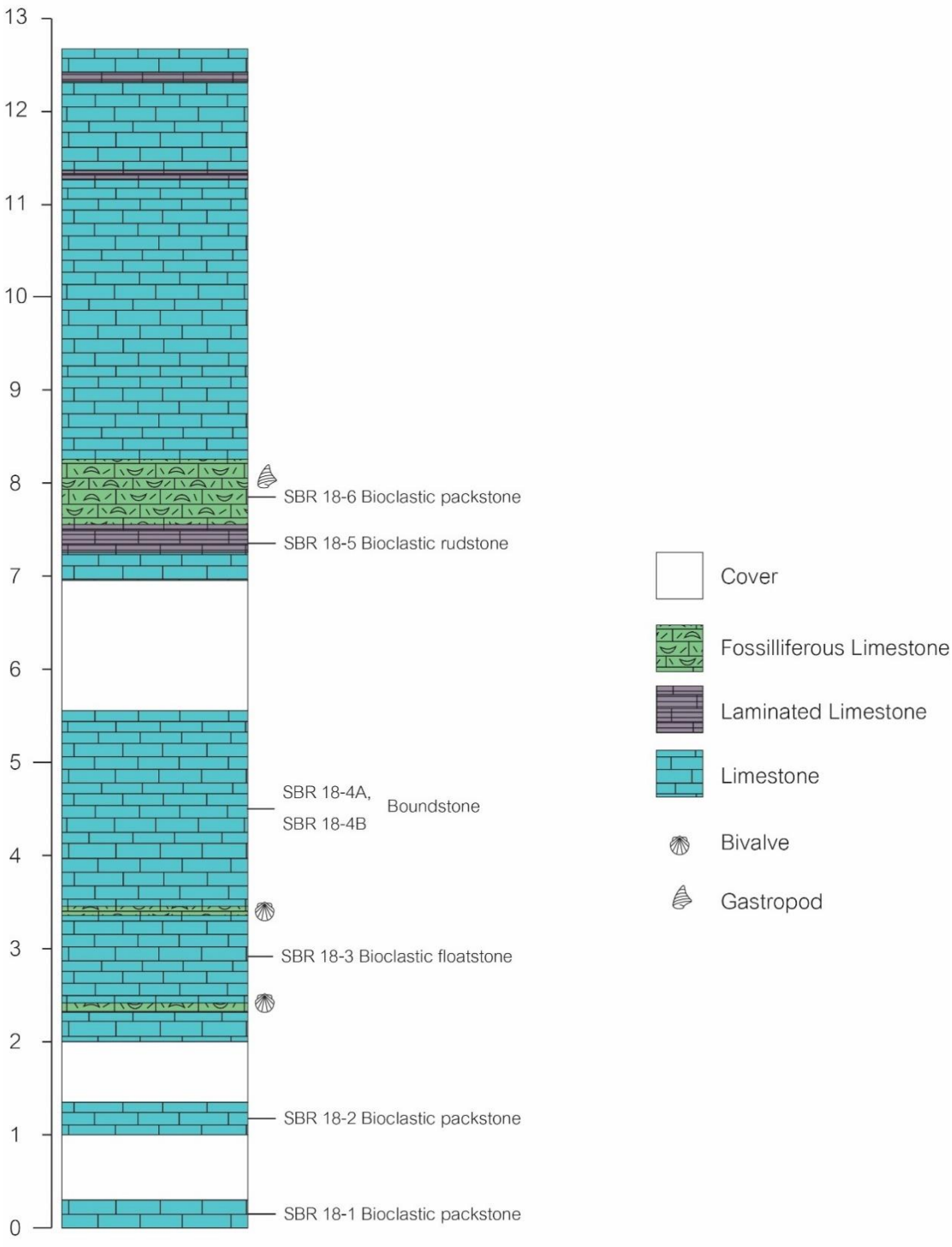

Figure 2.20 Stratigraphic column of SBR 18 shows interbedded of laminated limestone and thick bedded limestone.

SBR 39

The location of sample is at Khao Makok. It consists of dark grey, thin to medium bedded limestone with nodular cherts contact with sandstone. In microscopy, it consists bioclastic rudstone with fusulinid (*Robustoschwagerina* and *Parafusulina*) and crinoid. *Robustoschwagerina* in limestone is presented in Figure 2.24 and in thin section as Figure 2.25.

SBR 42

The rock exposed at foot hill of Khao Phra Phuttabat Noi. It is metamorphosed limestone. In microscopy, it presents augen in metamorphosed limestone. Fossils were no observed in this location.

SBR 43

The sample located at northwest of Khao Phra Phuttabat Noi. It is metamorphosed limestone with crinoid. Microscopically, Limestone shows metamorphosed with crinoids fragments.

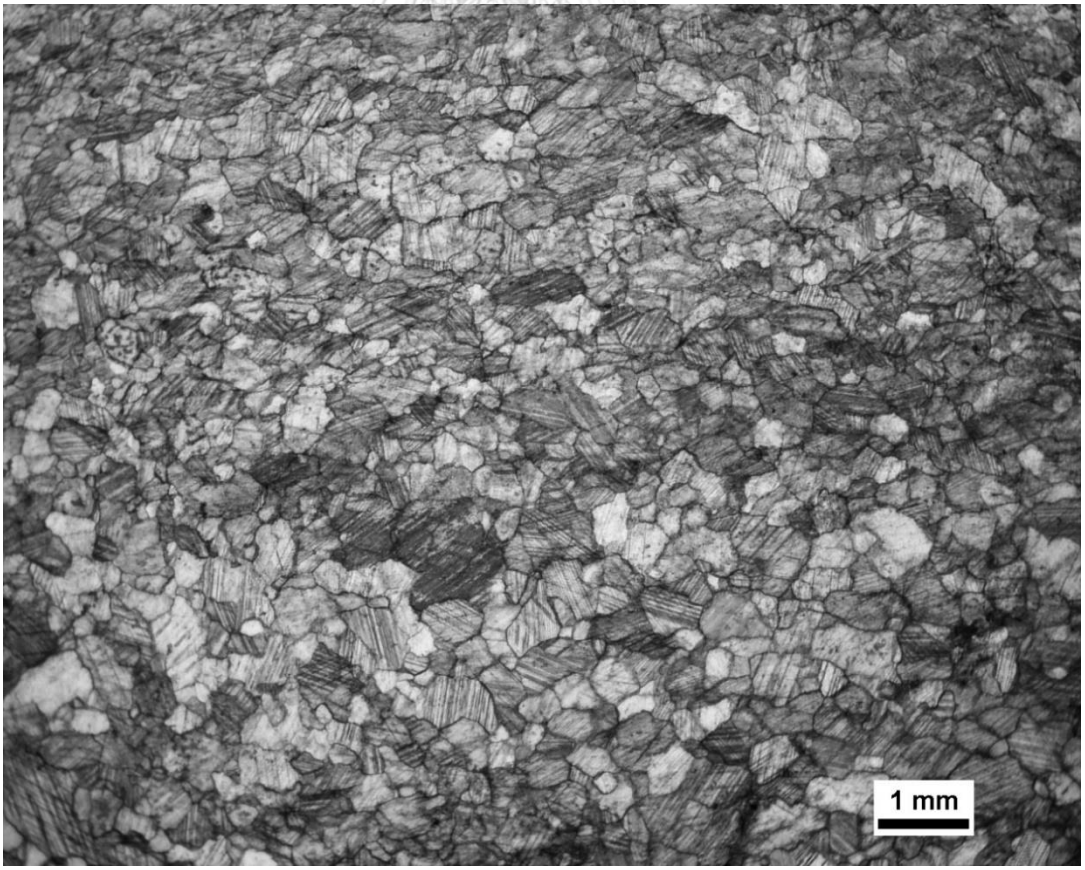

Figure 2.21 Photomicrograph of SBR 27 shows recrystallized texture in limestone.

Figure 2.22 Limestone at SBR 28 shows a lot of fusulinids can be observed by naked eyes.

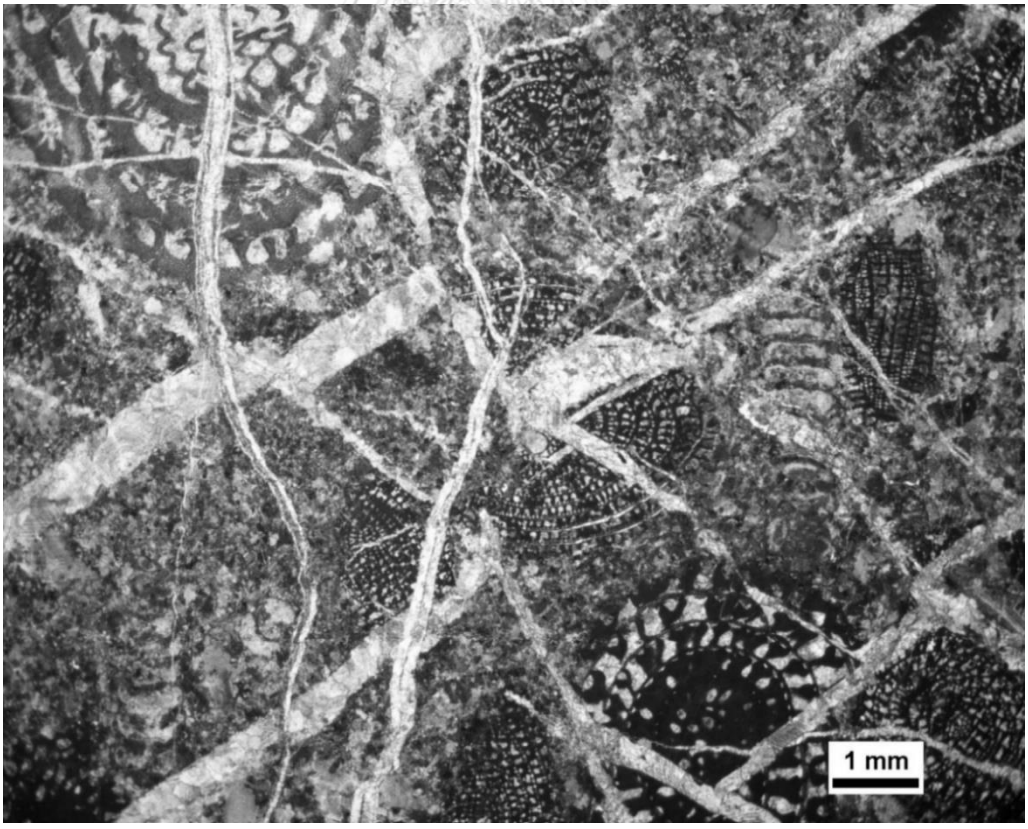

Figure 2.23 Photomicrograph of limestone at SBR 29 shows bioclastic rudstone and a lot of fractures were filled by calcite.

Figure 2.24 Outcrop at SBR 39 shows abundant of *Robustoschwagerina*.

Figure 2. 25 Photomicrograph of SBR 39 shows bioclastic rudstone with fusulinids (*Robustoschwagerina*) and sparry calcite cement.

2.2 Systematics paleontology

The fifteen species of the fifteen genera in five families of fusulinids were studied. The followings are identified and described as follows: -

Order Foraminiferida Eichwald, 1830

Suborder Fusulinina Wedekind, 1937

Superfamily Fusulinacea von Moller, 1878

Family Schubertellidae Skinner, 1931

Subfamily Fusulinellinae Staff and Wedekind, 1910

Genus *Yangchienia* J. S. Lee, 1934

Figure 2.25 (pics 1-5)

Yangchienia J. S. Lee, 1934, p. 14.

Yangchienia Loeblich and Tappan, 1988, pl. 269, figs. 8, 9.

Description: Shell is small with short axis of coiling and typically fusiform. Mature specimens of 7 volutions in oblique sections 1.43 to 2.20 mm in length and 1.31 to 1.36 mm in width, giving a form ratio of 1.05 to 1.68. The first volution, wall with tectum and proloculaus are absent. Septa thin and unfluted. Ratios of half length to radius vector of the seventh volutions in two specimens average 1.17, 1.20, 1.27, 1.35, 1.36, 1.81, 1.85, 1.91, 2.00, respectively. Asymmetrical chomata well developed and very massive in all volutions. Very thin spirotheca and have Thickness of the seven volutions in two specimens average 18-24 microns.

Materials: SBR 7A-4, SBR7D-4, SBR3-5A, SBR3-5B and SBR3-5C

Age: The range of the genus is Yakhtashian to Murgabian (Alfred R. Loeblich and Tappan, 1988)

Table 2.1 Measurement of *Yangchienia*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Thicness of Proloculus wall (microns)			
SBR 7A-4	1.43	1.36	1.05	0.00	0.00			
SBR 7D-4	2.20	1.31	1.68	0.00	0.00			
H.L. (mm)								
Spec. No.	1	2	3	4	5	6	7	8
SBR 7A-4	0.00	0.17	0.26	0.36	0.44	0.51	0.00	0.00
SBR 7D-4	0.00	0.00	0.43	0.64	0.85	1.20	1.32	0.00
R.V (mm)								
Spec. No.	1	2	3	4	5	6	7	8
SBR 7A-4	0.00	0.14	0.21	0.26	0.32	0.40	0.00	0.00
SBR 7D-4	0.00	0.00	0.22	0.34	0.46	0.60	0.73	0.00
H.L/R.V								
Spec. No.	1	2	3	4	5	6	7	8
SBR 7A-4	0.00	1.17	1.20	1.36	1.35	1.27	0.00	0.00
SBR 7D-4	0.00	0.00	1.91	1.85	1.85	2.00	1.81	0.00
Thickness of spirotheca (microns)								
Spec. No.	1	2	3	4	5	6	7	8
SBR 7A-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SBR 7D-4	0.00	0.00	18.37	18.37	18.37	23.62	23.62	0.00

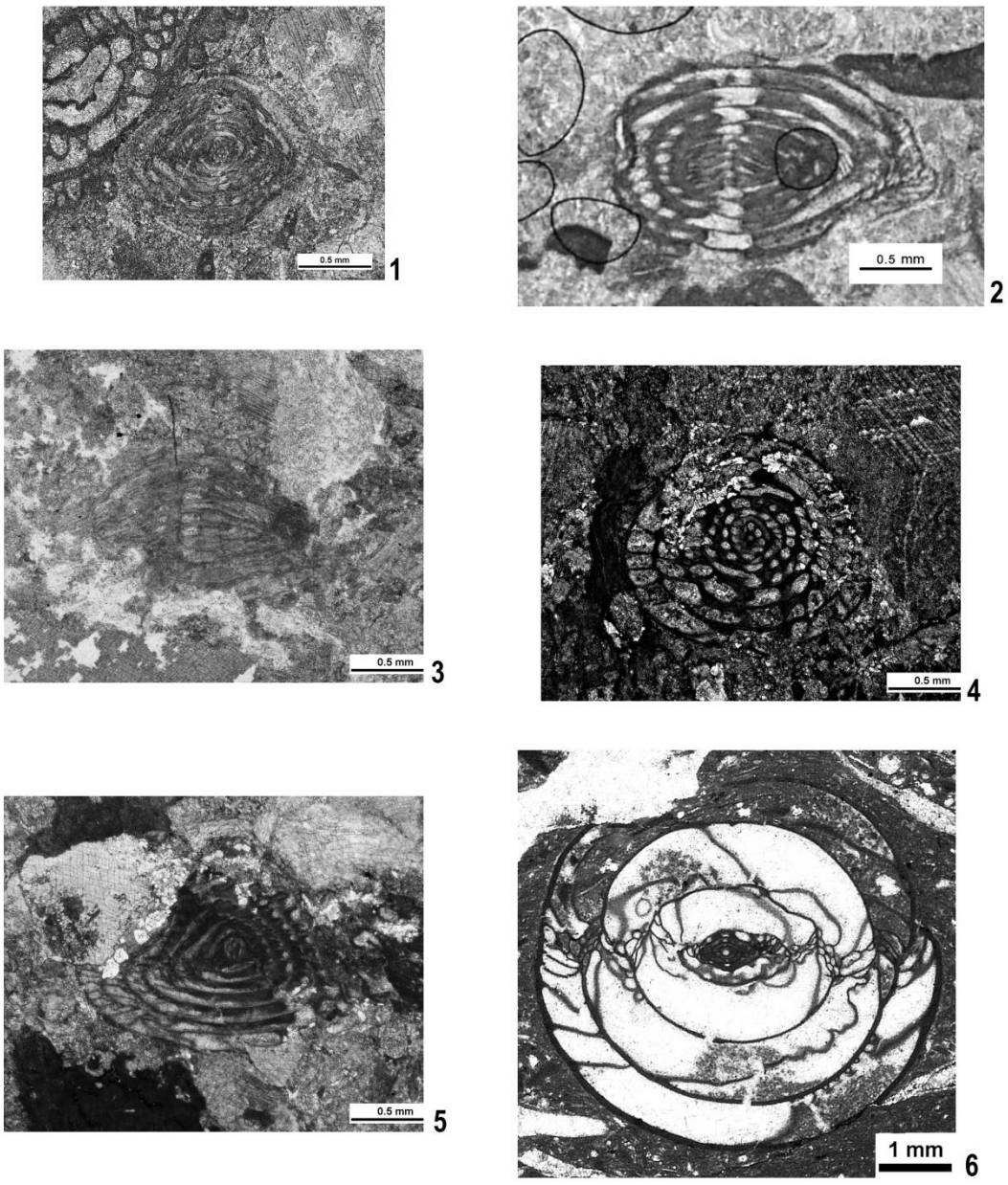

Figure 2.26 Fusulinids from Khao Khwang and Khao Khad formations, Saraburi province. (1-5) *Yangchienia* (1) Axial section, SBR7A-4. (2) Oblique section, SBR7D-4. (3) Oblique section, SBR3-5 A. (4) Oblique section, SBR3-5C. (5) Oblique section, SBR3-5B. (6) *Robustoschwagerina* (6) Axial section, SBR39-D.

Family Schwagerinidae Dunbar and Henbest, 1930

Subfamily Pseudoschwagerininae L. H. Chang, 1963

Genus *Robustoschwagerina* A.D. Miklukho-Maklay, 1959

Robustoschwagerina Leoblich and Tappan, 1988

Figure 2.25 (pics 6); Figure 2.26 (pics 1-4); Figure 2.27 (pics 1-3)

Robustoschwagerina A. D. Miklukho-Maklay, 1959, p. 160.

Robustoschwagerina A. D. Miklukho-Maklay, 1956, p. 1154 (name not available, ICZN Art. 13 (a)(i), no description).

Pseudoschwagerina (*Robustoschwagerina*) Igo, 1964, p. 287 (nom. transl).

Description: Test is large with subspherical shape with strongly umbilicate. Mature from 3 specimens in axial sections and 1 specimen in oblique section 5.56 to 6.02 mm in length and 5.04 to 6.20 mm in width, giving a form ratio of 0.97 to 1.10. Small proloculus with diameter 0.06 to 0.08 mm.

Materials: SBR 39-A, SBR 39-B, SBR 39-C, SBR 39-D, SBR 39-E, SBR 39-F, SBR 39-G

Age: Asselian (Alfred R. Loeblich and Tappan, 1988)

Table 2.2 Measurement of *Robustoschwagerina*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Proloculus wall (microns)
SBR 39A	6.02	6.20	0.97	0.06	10.50
SBR 39B	6.18	7.23	0.85	0.00	0.00
SBR 39C	6.45	6.69	0.96	0.08	10.39
SBR 39D	5.56	5.04	1.10	0.08	10.50

R.V (mm)					
Spec. No.	1	2	3	4	5
SBR 39A	0.51	1.39	2.56	3.45	3.93
SBR 39B	0.48	1.35	2.58	3.43	3.95
SBR 39C	0.48	1.44	2.62	3.43	0.00
SBR 39D	0.47	1.23	2.07	2.71	0.00

Thickness of spirotheca (microns)					
Spec. No.	1	2	3	4	5
SBR 39A	36.75	31.50	47.24	73.49	89.24
SBR 39B	36.75	36.75	47.24	110.24	120.73
SBR 39C	36.36	36.36	54.55	72.73	0.00
SBR 39D	36.75	36.75	47.24	55.12	0.00

H.L. (mm)					
Spec. No.	1	2	3	4	5
SBR 39A	1.54	2.12	2.84	3.39	3.73
SBR 39B	0.87	1.47	2.19	2.79	3.16
SBR 39C	1.71	2.09	2.61	3.35	0.00
SBR 39D	0.69	1.37	2.02	2.62	0.00

H.L/R.V					
Spec. No.	1	2	3	4	5
SBR 39A	3.03	1.52	1.11	0.98	0.95
SBR 39B	1.81	1.09	0.85	0.81	0.80
SBR 39C	3.61	1.45	1.00	0.98	0.00
SBR 39D	1.45	1.11	0.97	0.97	0.00

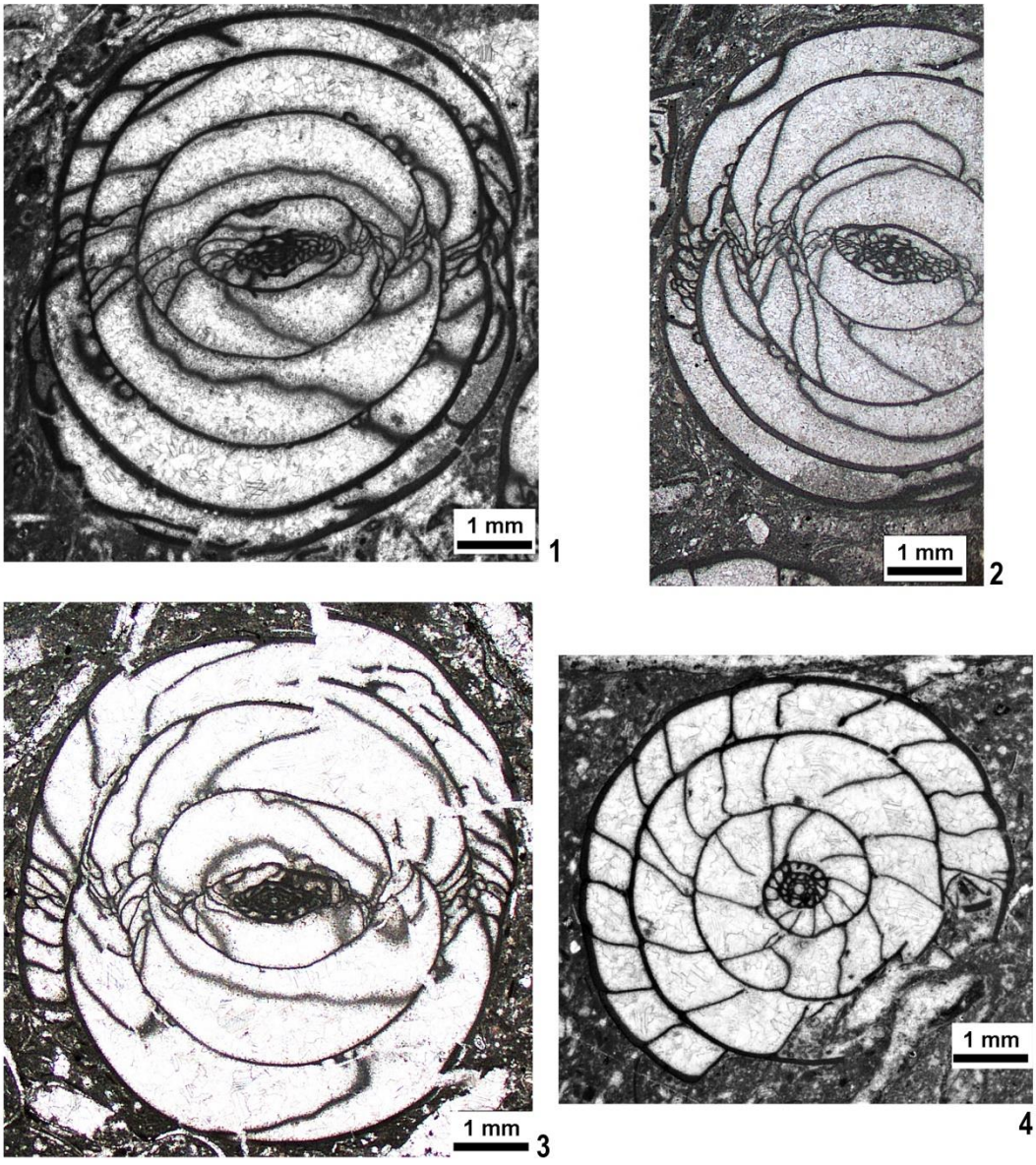

Figure 2.27 *Robustoschwagerina* from Khao Khad Formation. (1) Axial section, SBR39-B. (2) Axial section, SBR39-A. (3) Axial section, SBR39-C. (4) Sagittal section, SBR39D.

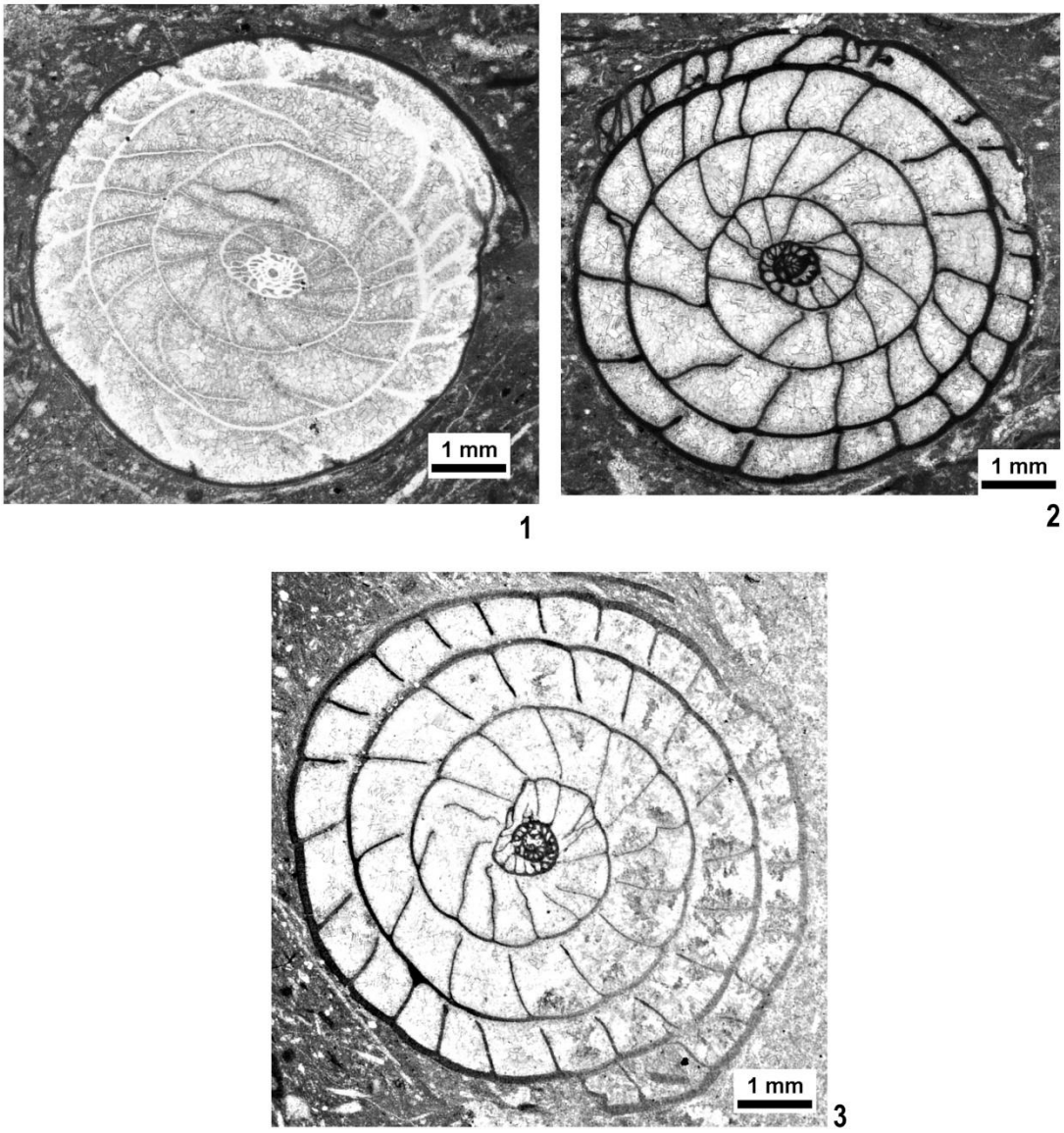

Figure 2.28 *Robustoschwagerina* from Khao Khad Formation. (1) Sagittal section, SBR39E. (2) Sagittal section, SBR39G. (3) Sagittal section, SBR39F.

Subfamily Schwagerininae Dunbar and Henbest, 1930

Genus *Parafusulina* Dunbar and Skinner, 1931

Parafusulina loeyensis Pitakpaivan, 1966

Figure 2.28 (pics 1, 2)

Parafusulina loeyensis Pitakpaivan, 1966, pl. 6, figs. 1-4.

Description: Elongate fusiform with moderately thick spirotheca and strong concavity that comprising of tectum and alveolar keriotheca. Septa commonly and hardly folded. The variable size of shell comprises 4 to 6 volutions with maximum 17.09 mm in length and 4.01 mm in width. Form ratio of 2 specimens are about 2.32 to 4.26. Proloculas wall thick, large and spherical that have diameters 0.44 and 0.51 mm. Thickness of spirotheca expands from 47-50 microns in the first volution to 102 microns in the last volution.

Materials: SBR 28C-2, SBR 30D-2

Age: Kungarian to Wordian (Toriyama and Kanmera, 1968)

Table 2.3 Measurement of *Parafusulina loeyensis*

Spec. No.	L (mm)	W (mm)	Form ratio	Proloculus (mm)	Proloculus wall (microns)
SBR 28C-2	17.09	4.01	4.26	0.51	18.37
SBR 30D-2	7.93	3.43	2.32	0.44	28.87

R.V (mm)						
Spec. No.	1	2	3	4	5	6
SBR 28C-2	0.66	1.08	1.52	2.04	2.06	2.42
SBR 30D-2	0.56	0.86	1.30	1.66	0.00	0.00

Thickness of spirotheca (microns)						
Spec. No.	1	2	3	4	5	6
SBR 28C-2	47.24	120.73	102.36	120.73	102.36	102.36
SBR 30D-2	49.87	73.49	81.36	89.24	0.00	0.00

H.L. (mm)						
Spec. No.	1	2	3	4	5	6
SBR 28C-2	0.95	1.57	2.27	3.08	5.25	6.82
SBR 30D-2	0.70	1.29	2.19	3.44	0.00	0.00

H.L/R.V						
Spec. No.	1	2	3	4	5	6
SBR 28C-2	1.45	1.45	1.49	1.51	2.55	2.82
SBR 30D-2	1.26	1.49	1.69	2.07	0.00	0.00

Parafusulina gigantea Toriyama, 1958

Figure 2.29 (pics 3-6); Figure 2.30 (pics 1, 2)

Fusulina gigantea Deprat, 1913, pp. 29-30, pl. 1, figs. 1-6.

Parafusulina gigantea Toriyama, 1958, pp. 200-203, pl. 36, figs. 2-11.

Parafusulina gigantea Toriyama and Sugi, 1959, pp. 19-21, pl. 1, figs. 1-5.

Parafusulina gigantea Sheng, 1963, p. 201, pl. 20, figs. 1-5, 9, 11; pl. 2, figs. 3-5.

Parafusulina gigantea Toriyama and Pitakpaivan, 1973, pp. 48-50, pl. 5, figs. 13-20.

Parafusulina gigantea Toriyama and Kanmera, 1979, pp. 44-46, pl. 5, figs. 10-13; pl. 6, figs. 1-6.

Description: The shell is elongate fusiform and large with straight axis of coiling. The first volution is subspherical and elongate fusiform in second to fifth volution. The shell of 2 specimens contain 5 volutions, with 7.77 and 8.34 mm in length and 3.53 mm in width, with a form ratio of 2.20 to 2.36. Large, ellipsoidal and spherical proloculus with diameter 0.24 to 0.35 mm and have structureless wall of 17 to 32 microns in thickness. Ratios of half length to radius vector of the first to fifth volutions average 2.08, 2.12, 2.14, 2.32, 2.43, 2.46, 2.48, 2.58 and 2.97. The thick spirotheca comprises of tectum and alveolar keriotheca and rapidly increases in thickness in third and fifth volution.

Materials: SBR 28B, SBR 30D

Age: middle of Middle Permian or Wordian (Toriyama and Kanmera, 1979)

Table 2.4 Measurement of *Parafusulina gigantea*

Spec. No.	L (mm)	W (mm)	Form ratio	Proloculus (mm)	Proloculus wall (microns)
SBR 28B	7.77	3.53	2.20	0.24	16.67
SBR 30D	8.34	3.53	2.36	0.35	31.78

R.V (mm)					
Spec. No.	1	2	3	4	5
SBR 28B	0.31	0.60	0.94	1.27	1.67
SBR 30D	0.39	0.67	1.08	1.43	1.83

Thickness of spirotheca (microns)					
Spec. No.	1	2	3	4	5
SBR 28B	50.00	85.71	104.76	126.19	133.33
SBR 30D	44.01	78.24	85.57	100.24	112.47

H.L. (mm)					
Spec. No.	1	2	3	4	5
SBR 28B	0.65	1.26	1.99	2.72	4.31
SBR 30D	1.16	1.67	2.50	3.52	4.45

H.L/R.V					
Spec. No.	1	2	3	4	5
SBR 28B	2.08	2.12	2.12	2.14	2.58
SBR 30D	2.97	2.48	2.32	2.46	2.43

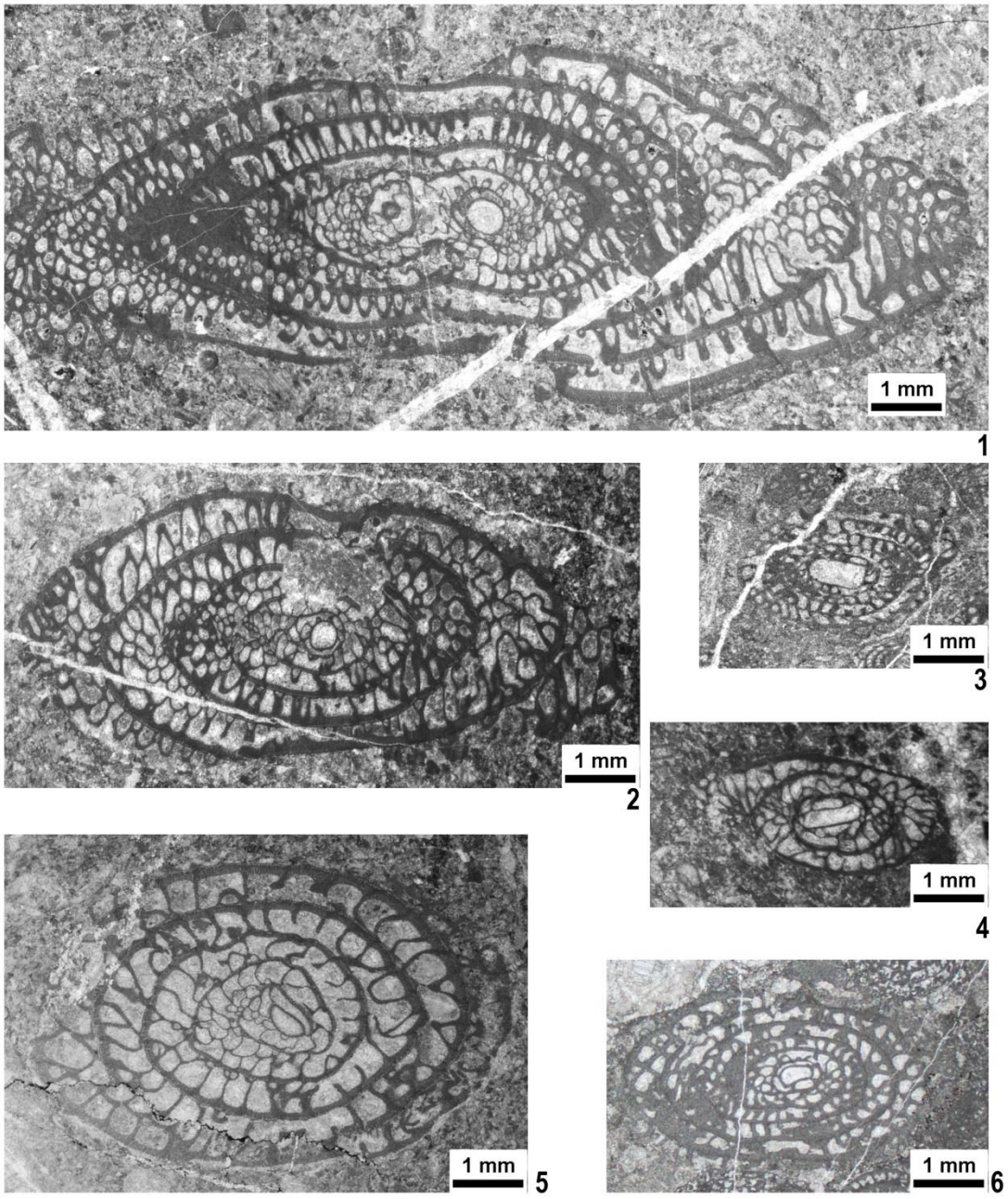

Figure 2.29 Fusulinids from Khao Khwang and Khao Khad formations. (1-2) *Parafusulina loeyensis.* (1) Axial section, SBR28C. (2) Axial section, SBR 30D-2. (3-6) *Parafusulina gigantea* (3) Sagittal section, SBR7A-2 (4) Sagittal section, SBR22B-5 (5) Sagittal section, SBR28E-17 (6) Sagittal section, SBR15C-3.

Genus *Laosella* Leven, 1997

Laosella edoensis Y. Ozawa, 1925

Figure 2.30 (pics 3)

Schellwienia edoensis Y. Ozawa, 1925, p. 31, 32, pl. 6, figs. 2, 3. pl. 6, fig. 1b (?).

Parafusulina edoensis (Y. Ozawa), Toriyama, 1958, p. 197-200, pl. 33, figs. 1-7; pl. 34, figs. 1-6; pl. 35, figs. 1-9; pl. 36, fig. 1.

Laosella edoensis (Y. Ozawa, 1925), Kobayashi, 2012, figs. 10.10-10.12, 10.15, 10.23.

Description: The very large shell and proloculus. Thick spirothecal wall and strongly folded septa. The variable size of shell comprises 6 volutions with maximum 14.52 mm in length and 4.25 mm in width, with a form ratio of 3.42. Diameter of Proloculus is 0.70 mm and thickness of Proloculus wall is 31 microns.

Materials: SBR 28E-8

Age: Murgabian to Midian (Kobayashi, 2012)

Table 2.5 Measurement of *Laosella edoensis*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Thicness of Proloculus wall (microns)
SBR 28E-8	14.52	4.25	3.42	0.70	31.50

H.L. (mm)					
Spec. No.	1	2	3	4	5	6
SBR 28E-8	1.09	1.95	2.96	4.19	6.45	7.07

H.L/R.V					
Spec. No.	1	2	3	4	5	6
SBR 28E-8	1.53	2.01	2.22	2.39	3.14	3.20

R.V (mm)					
Spec. No.	1	2	3	4	5	6
SBR 28E-8	0.71	0.97	1.33	1.75	2.06	2.20

Thickness of spirotheca (microns)					
Spec. No.	1	2	3	4	5	6
SBR 28E-8	47.24	65.62	91.86	76.12	118.11	91.86

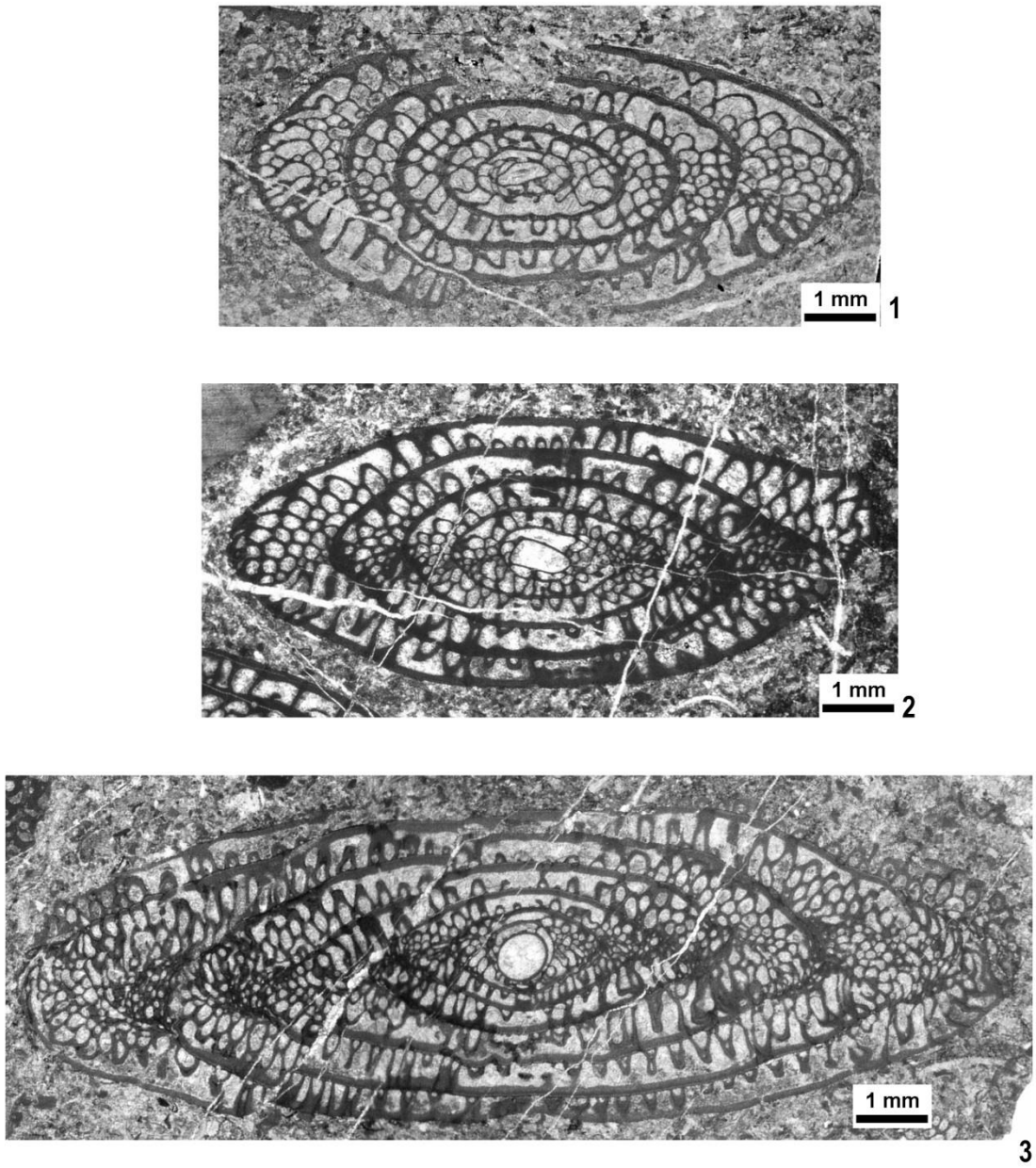

Figure 2.30 Fusulinids from Khao Khwang and Khao Khad formations. (1-2) *Parafusulina gigantea* (1) Axial section, SBR28B-1. (2) Axial section, SBR 30D-1. (3) *Laosella edoensis*, Axial section, SBR 28E.

Genus Pseudofusulina Dunbar and Skinner, 1931

Pseudofusulina Dunbar and Skinner, 1931

Figure 2.31 (pics 1-6)

Pseudofusulina Dunbar and Skinner, 1931, p. 252.

Pseudofusulina Loeblich and Tappan, 1988, pp. 278-279, pl. 281, figs. 1,2; pl. 282, figs. 1-7; pl. 283, figs. 1-6.

Description: Test large with elongate fusiform and axis of coiling straight. Length of 2 spicimens are 7.30 to 7.99 mm and 2.84 to 2.87 in width. Large proloculas with subspherical shape that have diameter 0.33 and 0.52 mm. Thickness of proloculus wall are 18 and 29 microns. Most strongly septa and folded. Thickness of spirotheca in the first to fifth volutions are 29, 37, 52, 66, 73, 76, 92 microns, respectively. Septa fluted are mostly u-shape forms.

Materials: SBR 5C-5, SBR 7A-5

Age: Asselian to Kungurian (Alfred R. Loeblich and Tappan, 1988)

Table 2.6 Measurement of *Pseudofusulina*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Proloculus wall (microns)
SBR 5C-5	7.30	2.84	2.57	0.52	18.37
SBR 7A-5	7.99	2.87	2.78	0.33	28.87

R.V (mm)					
Spec. No.	1	2	3	4	5
SBR 5C-5	0.53	0.53	0.99	1.24	1.53
SBR 7A-5	0.40	0.56	0.79	1.07	0.00

Thickness of spirotheca (microns)					
Spec. No.	1	2	3	4	5
SBR 5C-5	28.87	52.49	73.49	73.49	76.12
SBR 7A-5	36.75	65.62	73.49	91.86	0.00

H.L. (mm)					
Spec. No.	1	2	3	4	5
SBR 5C-5	0.52	0.89	1.77	2.80	3.97
SBR 7A-5	0.57	0.91	1.32	2.05	0.00

H.L/R.V					
Spec. No.	1	2	3	4	5
SBR 5C-5	0.99	1.69	1.78	2.25	2.60
SBR 7A-5	1.44	1.64	1.68	1.92	0.00

Subfamily Chusenellinae F. Kahler and G. Kahler, 1966

Genus *Chusenella* Hsu, 1942

Figure 2.31 (pics 7-9)

Chusenella Hsu, 1942, p. 175; OD.

Chusenella Lee, 1942, p. 171 (name not available, ICZN Art. 13 (b), no species included).

Description: The 4 specimens could not be identified to species because all of these are oblique sections. Size of shell are moderate and ovate fusiform to elongate fusiform with straight axis of coiling and strongly septa. Length of volutions average about 3.11 to 4.11 mm and a width of 1.63 to 2.08 mm, giving a minimum ratio of 1.71 and maximum ratio of 2.07. Spirotheca show wall structure of schwagerinid type that thickness of spirotheca, with average thickness of 17, 27, 32, 34, 47, 55, 66, 73, 79, 92, 101 microns in the first to sixth volutions, respectively, in four specimens. Chomata was developed in the second volution to the last volution.

Materials: SBR 12C-3, SBR 28C-7, SBR 38B, SBR 28E

Age: Late Permian to Upper Permian (Alfred R. Loeblich and Tappan, 1988)

Table 2.7 Measurement of *Chusenella*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Thicness of Proloculus wall (microns)
SBR 12C-3	4.11	2.08	1.98	0.00	0.00
SBR 28C-7	5.95	2.88	2.07	0.00	0.00
SBR 38B	4.14	2.43	1.71	0.00	0.00
SBR 28E	3.11	1.63	1.91	0.04	4.89

H.L. (mm)						
Spec. No.	1	2	3	4	5	6
SBR 12C-3	0.00	0.96	1.46	2.12	2.56	0.00
SBR 28C-7	0.00	1.02	1.58	2.19	2.67	0.00
SBR 38B	0.00	0.53	0.89	1.23	1.72	0.00
SBR 28E	0.18	0.30	0.45	0.00	1.01	1.27

R.V (mm)						
Spec. No.	1	2	3	4	5	6
SBR 12C-3	0.00	0.35	0.56	0.84	1.15	0.00
SBR 28C-7	0.00	0.49	0.81	1.07	1.42	0.00
SBR 38B	0.00	0.30	0.53	0.85	1.30	0.00
SBR 28E	0.10	0.15	0.22	0.36	0.57	0.76

H.L/R.V						
Spec. No.	1	2	3	4	5	6
SBR 12C-3	0.00	2.76	2.61	2.52	2.23	0.00
SBR 28C-7	0.00	2.07	1.96	2.04	1.88	0.00
SBR 38B	0.00	1.73	1.69	1.44	1.33	0.00
SBR 28E	1.90	2.05	2.08	0.00	1.77	1.67

Thickness of spirotheca (microns)						
Spec. No.	1	2	3	4	5	6
SBR 12C-3	0.00	46.75	72.73	72.73	101.30	0.00
SBR 28C-7	0.00	65.62	55.12	65.62	65.62	0.00
SBR 38B	0.00	65.62	55.12	78.74	91.86	0.00
SBR 28E	17.11	17.11	26.89	34.23	34.23	31.78

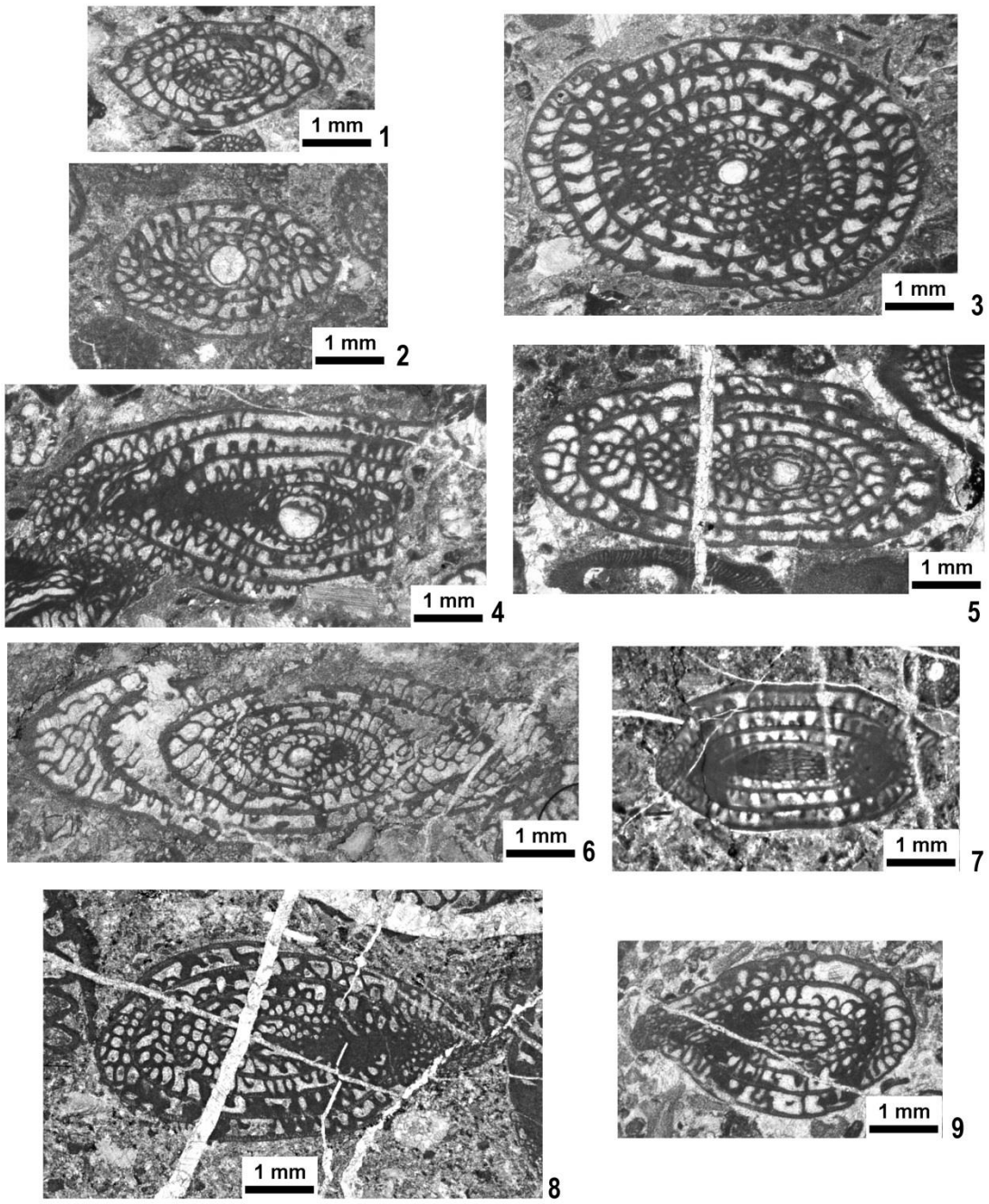

Figure 2.31 Fusulinids from Khao Khwang and Khao Khad formations. (1-6) *Pseudofusulina* (1) Sagittal section, SBR7D-10. (2) Sagittal section, SBR7D-11. (3) Sagittal section, SBR5C-3. (4) Axial section, SBR5C-5. (5) Sagittal section, SBR5A-1 (6) Axial section, SBR7A-5. (7-9) *Chusenella* (7) Oblique section, SBR12C-3 (8) Oblique section, SBR28C-7 (9) Oblique section, SBR38B

Chusenella chihsiaensis Lee, 1931

Figure 2.32 (pics 1)

Schellwienia chihsiaensis Lee, 1931, p. 287-288, pl. 1, figs. 2, 2a.

Pseudofusulina chihsiaensis, Chen, 1934, p. 74-75, pl. 9, figs. 1-8; pl. 10, fig. 18; pl. 11, fig. 10; pl. 14, figs. 11-12.

Pseudofusulina chihsiaensis, Saurin et Le-Thi-Vien, 1960, p. 293, pl. 1, figs. 19.

Chusenella chihsiaensis, Stewart, 1963, p.1162, pl. 158, figs. 2, 4.

Chusenella chihsiaensis, Toriyama, 1975, p. 41-43, pl. 11, figs. 1-11.

Chusenella chihsiaensis (Lee), Toriyama, 1977, pp. 6, pl. 1, Figs. 5,6.

Description: The specimens are represented by one of axial section. The shell are midiuma size with elongate fusiform, up to 5.72 mm in length and 1.85 mm in width. Small sized proloculus, 0.15 mm of diameter. Spirothecal wall thin with tectum and alveolar keriotheca. Chomata developed in all except the first volution.

Materials: SBR 28E

Age: Guadalapian (Yichun et al., 2009)

Table 2.8 Measurement of *Chusenella chihsiaensis*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Thicness of Proloculus wall (microns)		
SBR 28E	5.72	1.85	3.09	0.15	14.53		
H.L. (mm)							
Spec. No.	1	2	3	4	5	6	7
SBR 28E	0.78	0	0	0	0	0	0
R.V (mm)							
Spec. No.	1	2	3	4	5	6	7
SBR 28E	0.10	0.15	0.21	0.31	0.43	0.62	0.85
H.L/R.V							
Spec. No.	1	2	3	4	5	6	7
SBR 28E	7.67	0	0	0	0	0	0
Thickness of spirotheca (microns)							
Spec. No.	1	2	3	4	5	6	7
SBR 28E	19.37	19.37	31.48	33.90	50.85	70.22	77.48

Chusenella (*Chusenella*) *shengi* Toriyama and Kanmera, 1979

Figure 2.32 (pics 2)

Chusenella (*Chusenella*) *shengi* Toriyama and Kanmera, 1979, pp. 49-50, pl. 7, figs. 8-11.

Description: The shell is small with less elongate fusiform. This specimen have 6 volutions comprise a length of 3.83 mm and a width of 1.96 mm, giving a form ratio of 1.96. Ratios of half length to radius vector of first to sixth volutions are 2.35, 2.22, 2.40, 2.60, 1.46, respectively. Proloculus small with diameter of 0.13 mm. Thickness of spirotheca is moderate, with average of 21, 33, 36, 45, 36, 62 microns in the first to sixth volutions. Chomata weakly developed from the second volution.

Materials: SBR 28E

Age: Middle Permian (Toriyama and Kanmera, 1979)

Table 2.9 Measurement of *Chusenella* (*Chusenella*) *shengi*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Thicness of Proloculus wall (microns)	
SBR 28E	3.83	1.96	1.96	0.13	16.67	
H.L. (mm)						
Spec. No.	1	2	3	4	5	6
SBR 28E	0.34	0.54	0.80	1.29	1.04	0.00
R.V (mm)						
Spec. No.	1	2	3	4	5	6
SBR 28E	0.14	0.24	0.34	0.50	0.71	0.94
H.L/R.V						
Spec. No.	1	2	3	4	5	6
SBR 28E	2.35	2.22	2.40	2.60	1.46	0.00
Thickness of spirotheca (microns)						
Spec. No.	1	2	3	4	5	6
SBR 28E	21.43	33.33	35.71	45.24	35.71	61.90

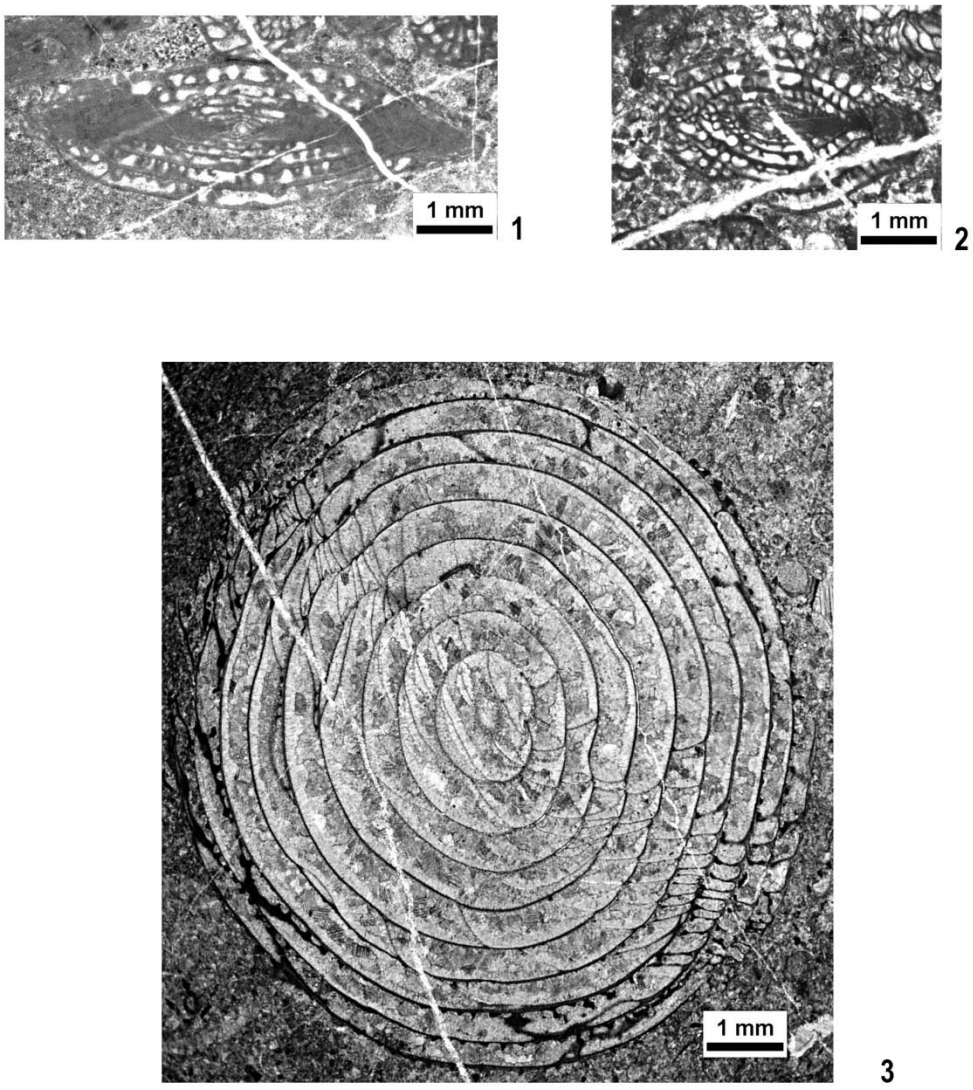

Figure 2.32 Fusulinids from Khao Khwang and Khao Khad formations. (1) *Chusenella chihsiaensis*, Axial section, SBR 7A-13. (2) *Chusenella* (*Chusenella*) *shengi*, Axial section, SBR 22B-8. (3) *Verbeekina verbeeki* (Geinitz), Oblique section, SBR3-2-7.

Family Verbeekinidae Staff and Wedekind, 1910

Subfamily Verbeekininae Staff and Wedekind, 1910

Genus *Verbeekina* Staff, 1909

Verbeekina verbeeki (Geinitz), 1876

Figure 2.32 (pics 3); Figure 2.33 (pics 1, 2); Figure 2.34 (pics 1)

Fusulina verbeeki Geinitz, 1876, pp. 399-400.

Verbeekina verbeeki Ozawa, 1925, pp. 48-51, pl. 10, figs. 6-7.

Verbeekina verbeeki Thompson, 1936, pp. 197-200, pl. 24, figs. 1-8.

Verbeekina verbeeki Chen, 1956, pp. 47-48, pl. 4, figs. 5-6; pl. 8, Figs. 1-2.

Verbeekina verbeeki Toriyama and Pitakpaivan, 1973, pp. 50-53, pl. 6, figs. 1-5.

Description: The shell is spherical. Length of three specimens are 5.70, 7.75 and 9.51 mm and 7.66, 7.85,10.86 mm in width with form ratios of 0.74, 0.99, 0.8, respectively in the first to eleventh volutions. The proloculus are absent. The average radius vectors of the first to eleventh in 3 specimens are 0.42, 0.83, 1.24, 1.25, 1.64, 2.02, 2.34, 2.65, 2.96, 3.24 and 5.11 mm. The thin spirotheca comprising wall of tectum and extremely fine alveolar keriotheca. The thin septa are unfluted throughout the length of the shell. The thickness of the spirotheca of the first to eleventh volutions in one specimen (SBR 12C-15) measures 40, 26, 26, 26, 26, 21, 28, 43, 45, 59 and 50 microns, respectively. Parachomata are developed in eight to tenth volutions.

Materials: SBR 3-2, SBR 12A-7, SBR 12C-15

Age: middle to upper Middle Permian

Table 2.10 Measurement of *Verbeekina verbeeki*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Thicness of Proloculus wall (microns)	H.L. (mm)										
						Spec. No.	1	2	3	4	5	6	7	8	9	10	11
SBR 3-2	5.70	7.66	0.74	0.00	0.00	SBR 3-2	0.73	1.22	1.68	2.09	2.53	3.00	3.40	3.74	4.03	4.28	0.00
SBR 12A-7	7.75	7.85	0.99	0.00	0.00	SBR 12A-7	0.42	0.76	1.10	1.60	2.35	2.81	3.25	3.63	2.44	3.97	0.00
SBR 12C-15	9.51	10.86	0.88	0.00	0.00	SBR 12C-15	0.19	0.46	0.85	1.22	1.82	2.43	2.99	3.55	4.05	4.43	4.65
R.V (mm)																	
Spec. No.	1	2	3	4	5	6	7	8	9	10	11						
SBR 3-2	0.64	1.04	1.47	0.48	0.58	0.68	0.76	0.83	0.90	0.98	0.00						
SBR 12A-7	0.34	0.86	1.30	1.81	2.38	2.85	3.07	3.32	3.64	4.01	0.00						
SBR 12C-15	0.28	0.58	0.97	1.46	1.97	2.53	3.19	3.81	4.33	4.73	5.11						
H.L/R.V																	
Spec. No.	1	2	3	4	5	6	7	8	9	10	11						
SBR 3-2	1.14	1.17	1.14	4.30	4.34	4.43	4.48	4.53	4.47	4.35	0.00						
SBR 12A-7	1.23	0.89	0.85	0.88	0.99	0.99	1.06	1.09	0.67	0.99	0.00						
SBR 12C-15	0.68	0.79	0.88	0.83	0.92	0.96	0.94	0.93	0.94	0.94	0.91						
Thickness of spirotheca (microns)																	
Spec. No.	1	2	3	4	5	6	7	8	9	10	11						
SBR 3-2	21.28	21.28	30.73	26.00	33.10	26.00	26.00	42.55	26.00	26.00	0.00						
SBR 12A-7	30.44	32.79	21.08	21.08	37.47	49.18	49.18	49.18	46.84	42.15	0.00						
SBR 12C-15	40.19	26.00	26.00	26.00	26.00	21.28	28.37	42.55	44.92	59.10	49.65						

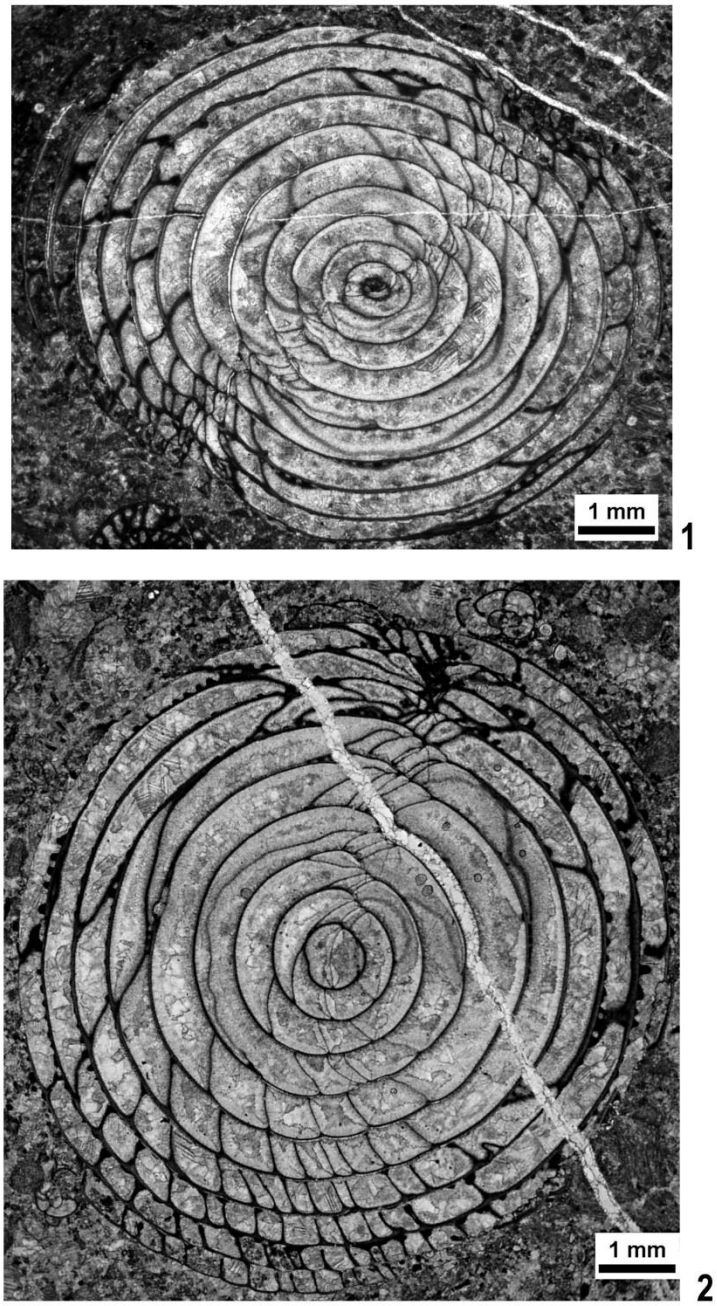

Figure 2.33 Representative of *Verbeekina verbeeki* (Geinitz) (1) Oblique section, SBR12C-15. (2) Oblique section, SBR12A-7.

Subfamily Miselllininae A. D. Miklukho-Maklay, 1958

Genus *Misellina* Schenck and Thompson, 1940

Figure 2.34 (pics 2)

Misellina Schenck and Thompson, 1940, p. 587.

Description: The shell is too small and subspherical shape. Small proloculus, thick spirothecal wall with low parachomata.

Materials: SBR 38H

Age: Sakmarian to Artinskian (Alfred R. Loeblich and Tappan, 1988)

Subfamily Pseudodoliolininae Leven, 1963

Genus *Pseudodoliolina* Yabe and Hanzawa, 1932

Figure 2.34 (pics 3, 4)

Pseudodoliolina Yabe and Hanzawa, 1932, p.41.

Description: The shell is medium size ,elongate subcyclindrical fusiform with bluntly to broadly rounded poles. Proloculus is absent in this specimen because It is a oblique section. The ten volutions is 4.95 mm in length and 2.08 mm in width, giving a form ratio of 1.16. Half length of the first to tenth volutions measures 0.30, 0.63, 0.78, 0.97, 1.18, 1.42, 1.76, 1.93, 2.15 and 2.43 mm, respectively. Ratios of half length to radius vector of the first to tenth volutions 2.51, 3.53, 3.24, 2.83, 2.82, 2.82, 2.86, 2.66, 2.52 and 2.42, respectively. Spirothecal wall is thin with thickness 17, 17, 17, 17, 17, 17, 22, 22, 29 and 29 microns. Parachomata occur in inner fourth to last volutions.

Materials: SBR 38H

Age: upper Middle Permian (Toriyama and Kanmera, 1977)

Table 2.11 Measurement of *Pseudodoliolina*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Thicness of Proloculus wall (microns)					
SBR 38H	4.95	2.08	2.37	0.00	0.00					
H.L. (mm)										
Spec. No.	1	2	3	4	5	6	7	8	9	10
SBR 38H	0.30	0.63	0.78	0.97	1.18	1.42	1.76	1.93	2.15	2.43
R.V (mm)										
Spec. No.	1	2	3	4	5	6	7	8	9	10
SBR 38H	0.12	0.18	0.24	0.34	0.42	0.50	0.62	0.73	0.85	1.01
H.L/R.V										
Spec. No.	1	2	3	4	5	6	7	8	9	10
SBR 38H	2.51	3.53	3.24	2.83	2.82	2.82	2.86	2.66	2.52	2.42
Thickness of spirotheca (microns)										
Spec. No.	1	2	3	4	5	6	7	8	9	10
SBR 38H	16.95	16.95	16.95	16.95	16.95	16.95	21.79	21.79	29.06	29.06

Family Neoschwagerinidae Dunbar and Condra, 1927

Subfamily Thailandininae Toriyama and Kanmera, 1968

Genus *Thailandina* Toriyama and Kanmera, 1968

Thailandina buravasi Toriyama and Kanmera, 1968

Figure 2.34 (pic 5, 6)

Thailandina buravasi Toriyama and Kanmera, 1968, pp. 32-33, pl. 6, figs. 1-15.

Description: Shell is small, poles bluntly pointed. Mature in 3 specimens 3.75 to 3.68 mm in length and 1.71 to 1.94 mm in width, with form ratios of 1.89 to 2.19. Diameter of proloculus is range from 0.17 to 0.19 mm. Outer structure of spirothecal wall and septa almost replaced and destroyed by secondary replacement. Spirotheca is thin and septa is thick with unfluted throughout growth of shell.

Materials: SBR 22B-10, SBR 22B-14-1, SBR 22B-14-2

Age: Kubergandian to Murgabian (Toriyama and Kanmera, 1968)

Table 2.12 Measurement of *Thailandina buravasi*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Thicness of Proloculus wall (microns)	
SBR 22B-10	3.75	1.71	2.19	0.19	18.37	
SBR 22B-14 1	3.80	2.13	1.78	0.19	0.00	
SBR 22B-14 2	3.68	1.94	1.89	0.17	18.37	
H.L. (mm)						
Spec. No.	1	2	3	4	5	6	7
SBR 22B-10	0.35	0.56	0.81	1.08	1.29	1.48	1.67
SBR 22B-14 1	0.29	0.45	0.63	0.90	1.19	1.47	1.81
SBR 22B-14 2	0.22	0.34	0.59	0.89	1.19	1.50	1.77
R.V (mm)							
Spec. No.	1	2	3	4	5	6	7
SBR 22B-10	0.18	0.03	0.38	0.44	0.55	0.69	0.81
SBR 22B-14 1	0.14	0.23	0.36	0.50	0.65	0.82	1.00
SBR 22B-14 2	0.27	0.35	0.45	0.54	0.65	0.78	0.97
H.L/R.V							
Spec. No.	1	2	3	4	5	6	7
SBR 22B-10	2.00	16.54	2.14	2.44	2.36	2.16	2.07
SBR 22B-14 1	2.06	1.97	1.74	1.79	1.83	1.79	1.81
SBR 22B-14 2	0.83	0.98	1.31	1.65	1.84	1.93	1.82

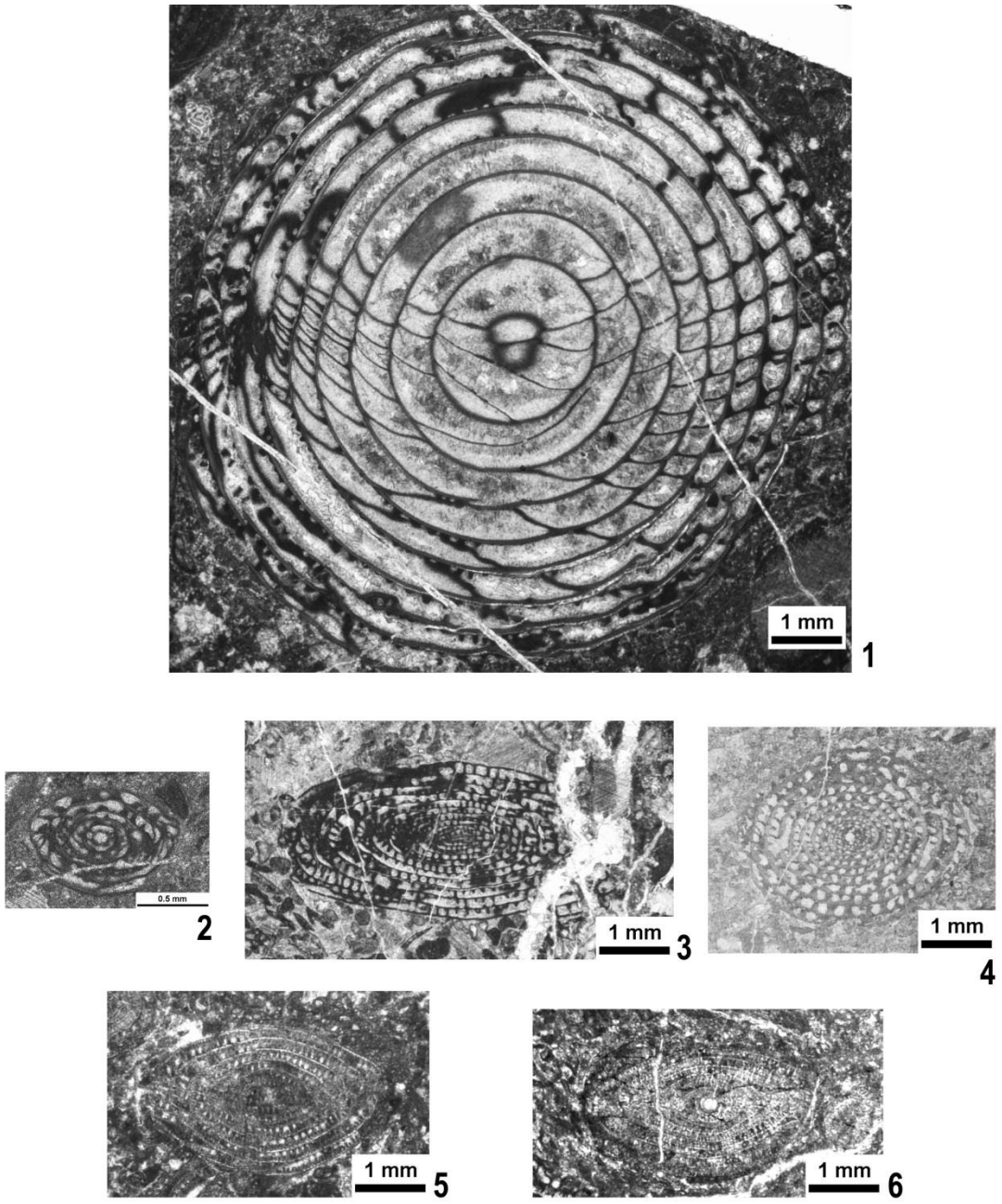

Figure 2.34 Fusulinids from Khao Khwang and Khao Khad formations. (1) *Verbeekina verbeeki* (Geinitz), Oblique section, SBR11B-7. (2) *Misellina*, Sagittal section, SBR5B-1. (3-4) *Pseudodoliolina* (3) Sagittal section, SBR38H-1. (4) Sagittal section, SBR15D-6. (5-6) *Thailandina buravasi* (5) Axial section,SBR 22B-14. (6) Axial section, SBR 22B-10.

Subfamily Neoschwagerininae Dunbar and Condra, 1927

Genus *Neoschwagerina* Yabe, 1903

Neoschwagerina megasphaerica Deprat, 1913

Figure 2.35 (pics 1-5)

Neoschwagerina megasphaerica Deprat, 1913, p. 57, pl. 7, fig. 26, pl. 9, figs. 4-8.

Neoschwagerina megasphaerica Colani, 1924, p.126 et 158, pl. 2, figs. 1-23.

Neoschwagerina megasphaerica Ozawa, 1925, p. 58, pl. 11, fig. 8.

Neoschwagerina megasphaerica Chen, 1956, pp. 63, 64, pl. 10, figs. 4-8.

Neoschwagerina megasphaerica Toriyama, 1956, p. 227-230, pl. 42, figs. 7-14; pl. 43, figs. 1-5.

Neoschwagerina megasphaerica Pitakpaivan, 1966, pp. 114-116, pl. 6, figs. 6-9.

Description: Shell is medium size, subspherical that volution increases in height towards with bluntly rounded poles. Measurement of 5 specimens have 2.40 to 3.15 mm in length and 1.13 to 1.57 mm in width, with form ratios of 1.81 to 2.27. Proloculus is large and spherical, 0.21 to 0.31 mm in diameter, thickness of proloculus wall 18-24 microns. The parachomata forming in the axial section.

Materials: SBR 13D-2, SBR 15D-4, SBR 15D-7, SBR 15D-8, SBR 15D-12

Age: Capitanian (Pitakpaivan, 1966)

Table 2.13 Measurement of *Neoschwagerina megasphaerica*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Thicness of Proloculus wall (microns)	H.L. (mm)											
SBR 13D-2	2.85	1.57	1.81	0.30	18.37	SBR 13D-2	0.24	0.32	0.44	0.64	0.84	1.09	1.22	1.37			
SBR 15D-4	2.97	1.44	2.06	0.22	23.62	SBR 15D-4	0.27	0.41	0.63	0.82	1.11	1.31	1.48	0.00			
SBR 15D-7	2.92	1.29	2.27	0.21	18.37	SBR 15D-7	0.34	0.55	0.81	1.00	1.47	1.72	0.00	0.00			
SBR 15D-8	2.40	1.13	2.13	0.31	23.62	SBR 15D-8	0.27	0.58	0.91	1.05	1.20	0.00	0.00	0.00			
SBR 15D-12	3.15	1.51	2.09	0.23	18.37	SBR 15D-12	0.29	0.44	0.63	0.83	1.11	1.33	1.50	0.00			

R.V (mm)									H.L/R.V								
Spec. No.	1	2	3	4	5	6	7	8	Spec. No.	1	2	3	4	5	6	7	8
SBR 13D-2	0.22	0.27	0.33	0.39	0.47	0.55	0.65	0.77	SBR 13D-2	1.08	1.21	1.31	1.64	1.78	2.00	1.89	1.78
SBR 15D-4	0.20	0.28	0.36	0.49	0.59	0.00	0.00	0.00	SBR 15D-4	1.32	1.46	1.74	1.68	1.87	0.00	0.00	0.00
SBR 15D-7	0.21	0.29	0.39	0.50	0.60	0.00	0.00	0.00	SBR 15D-7	1.62	1.91	2.07	1.99	2.45	0.00	0.00	0.00
SBR 15D-8	0.21	0.30	0.39	0.48	0.61	0.00	0.00	0.00	SBR 15D-8	1.27	1.96	2.34	2.18	1.97	0.00	0.00	0.00
SBR 15D-12	0.19	0.19	0.44	0.56	0.65	0.73	0.85	0.00	SBR 15D-12	1.47	2.24	1.42	1.48	1.71	1.82	1.76	0.00

Thickness of spirotheca (microns)									Septal count								
Spec. No.	1	2	3	4	5	6	7	8	Spec. No.	1	2	3	4	5	6	7	8
SBR 13D-2	23.62	23.62	23.62	23.62	23.62	23.62	23.62	23.62	SBR 13D-2	0	0	0	34	49	50	0	0
SBR 15D-4	18.37	18.37	18.37	15.75	18.37	0.00	0.00	0.00	SBR 15D-4	12	17	0	34	0	0	0	0
SBR 15D-7	10.50	18.37	18.37	18.37	0.00	0.00	0.00	0.00	SBR 15D-7	16	17	22	24	30	0	0	0
SBR 15D-8	18.37	18.37	23.62	23.62	23.62	0.00	0.00	0.00	SBR 15D-8	11	23	31	0	0	0	0	0
SBR 15D-12	18.37	18.37	18.37	23.62	23.62	23.62	23.62	0.00	SBR 15D-12	10	18	30	32	39	0	0	0

Genus *Colania* Lee, 1934

Colania douvillei (Ozawa), 1922

Figure 2.35 (pics 6-12); Figure 2.36 (pics 1, 2)

Colania douvillei T. Ozawa,1970a, pp. 50-51, pl. 7, figs. 8-10.

Colania douvillei T. Ozawa, 1970b, pp. 35-39, pl. 3, figs. 1-10; pl. 4, figs. 1-10; pl. 5, figs. 1-5; pl. 6, figs. 1-9.

Colania douvillei Toriyama,1976, pp. 103-104, pl. 20, figs. 22-26.

Colania douvillei Toriyama and Kanmera, 1977, pp. 17-24, pl. 2, figs. 7-17; pl. 3, figs. 1-16.

Description: Shell is moderate size with inflated fusiform. The mature shells of 10 to 13 volutions contain a length of 3.45 to 6.69 mm and a width of 2.07 to 3.22 mm, with a form ratio of 1.44 to 2.29. Proloculus is moderate in size with spherical to subspherical form. Diameter of proloculus varies from 0.30 to 0.79 mm. The layer of keriotheca and thin layer of tectum contains in spirotheca with clear structure of alveolar keriotheca. Average thickness of spirotheca of ten specimens in the first to thirteenth volutions 13 to 17 microns.

Materials: SBR 10-2, SBR 2A, SBR 10-2, SBR 10-2 1, SBR 10-2 4, SBR 10-2 10, SBR 10-2 14, SBR 10-2 26, SBR 10-2 27, SBR 10-2 29, SBR 10-2 34

Age: Lower to Middle Capitanian (Toriyama and Kanmera, 1977)

Table 2.14 Measurement of *Colania douvillei*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Thickness of Prolloculus wall (microns)	H.L. (mm)													
						Spec. No.	1	2	3	4	5	6	7	8	9	10	11	12	13
SBR 10-2	6.38	2.95	2.16	0.56	18.37	SBR 10-2	0.39	0.56	0.80	1.00	1.15	1.30	1.60	1.90	2.21	2.45	2.67	2.93	3.10
SBR 2A	6.00	3.22	1.86	0.74	26.63	SBR 2A	0.51	0.67	0.91	1.12	1.36	1.69	1.98	2.26	2.52	2.68	2.80	0.00	0.00
SBR 10-2	6.49	2.84	2.29	0.30	17.11	SBR 10-2	0.24	0.37	0.57	0.85	1.05	1.36	1.78	2.16	2.60	3.07	3.52	3.79	0.00
SBR 10-2 1	6.69	3.10	2.16	0.79	18.57	SBR 10-2 1	0.56	0.76	0.91	1.08	1.31	1.57	1.93	2.03	2.61	2.98	3.28	0.00	0.00
SBR 10-2 4	4.64	3.17	1.46	0.30	18.37	SBR 10-2 4	0.30	0.44	0.55	0.70	0.88	1.07	1.31	1.54	1.76	1.93	2.04	2.11	0.00
SBR 10-2 10	4.72	2.62	1.80	0.53	18.37	SBR 10-2 10	0.34	0.44	0.60	0.76	0.93	1.10	1.32	1.59	1.93	2.16	2.52	2.72	0.00
SBR 10-2 14	4.59	3.19	1.44	0.31	18.37	SBR 10-2 14	0.26	0.43	0.66	0.92	1.09	1.33	1.54	1.79	2.07	2.26	2.46	0.00	0.00
SBR 10-2 26	3.93	2.68	1.47	0.43	15.75	SBR 10-2 26	0.30	0.43	0.54	0.70	0.84	0.99	1.19	1.42	1.56	1.82	0.00	0.00	0.00
SBR 10-2 27	3.45	2.07	1.67	0.36	15.75	SBR 10-2 27	0.29	0.39	0.51	0.64	0.75	0.92	1.07	1.30	1.46	1.66	0.00	0.00	0.00
SBR 10-2 29	3.95	2.66	1.49	0.42	18.37	SBR 10-2 29	0.30	0.44	0.54	0.69	0.83	0.98	1.19	1.37	1.59	1.84	0.00	0.00	0.00
SBR 10-2 34	3.65	2.30	1.59	0.30	15.75	SBR 10-2 34	0.30	0.44	0.65	0.82	1.12	1.18	1.40	1.67	0.00	0.00	0.00	0.00	0.00

	R.V (mm)													H.L/R.V												
Spec. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	Spec. No.	1	2	3	4	5	6	7	8	9	10	11	12	13
SBR 10-2	0.32	0.38	0.43	0.54	0.65	0.75	0.84	0.92	1.00	1.09	1.20	1.35	1.49	SBR 10-2	1.20	1.46	1.87	1.86	1.77	1.74	1.90	2.07	2.21	2.25	2.21	2.17	2.08
SBR 2A	0.50	0.61	0.73	0.86	0.99	1.13	1.26	1.41	1.55	1.56	1.66	0.00	0.00	SBR 2A	1.03	1.10	1.24	1.30	1.37	1.50	1.58	1.61	1.63	1.72	1.69	0.00	0.00
SBR 10-2	0.22	0.30	0.38	0.48	0.58	0.68	0.78	0.90	1.03	1.17	1.31	1.42	0.00	SBR 10-2	1.08	1.24	1.50	1.75	1.82	2.00	2.30	2.39	2.54	2.62	2.68	2.67	0.00
SBR 10-2 1	0.40	0.49	0.58	0.66	0.75	0.86	0.96	1.10	1.22	1.31	1.42	0.00	0.00	SBR 10-2 1	1.39	1.56	1.56	1.62	1.75	1.82	2.00	1.85	2.14	2.27	2.30	0.00	0.00
SBR 10-2 4	0.30	0.39	0.49	0.62	0.74	0.86	1.01	1.14	1.28	1.41	1.54	1.67	0.00	SBR 10-2 4	1.00	1.14	1.11	1.14	1.19	1.25	1.30	1.35	1.38	1.37	1.32	1.27	0.00
SBR 10-2 10	0.32	0.40	0.48	0.57	0.67	0.77	0.86	0.94	1.06	1.18	1.32	0.00	0.00	SBR 10-2 10	1.07	1.11	1.25	1.32	1.40	1.43	1.54	1.69	1.83	1.83	1.90	0.00	0.00
SBR 10-2 14	0.26	0.37	0.46	0.58	0.72	0.84	0.84	1.08	1.22	1.38	1.53	0.00	0.00	SBR 10-2 14	1.00	1.15	1.42	1.57	1.51	1.58	1.83	1.65	1.69	1.64	1.61	0.00	0.00
SBR 10-2 26	0.29	0.36	0.45	0.54	0.69	0.82	0.94	1.10	1.08	1.24	0.00	0.00	0.00	SBR 10-2 26	1.06	1.17	1.18	1.29	1.23	1.20	1.26	1.29	1.45	1.47	0.00	0.00	0.00
SBR 10-2 27	0.22	0.32	0.39	0.46	0.53	0.64	0.74	0.85	1.00	0.00	0.00	0.00	0.00	SBR 10-2 27	1.28	1.20	1.31	1.39	1.42	1.44	1.44	1.53	1.46	0.00	0.00	0.00	0.00
SBR 10-2 29	0.33	0.42	0.51	0.61	0.73	0.84	0.99	1.09	1.25	0.00	0.00	0.00	0.00	SBR 10-2 29	0.91	1.04	1.06	1.12	1.14	1.17	1.20	1.25	1.28	0.00	0.00	0.00	0.00
SBR 10-2 34	0.26	0.37	0.49	0.63	0.78	0.90	1.02	1.19	0.00	0.00	0.00	0.00	0.00	SBR 10-2 34	1.13	1.20	1.32	1.31	1.44	1.31	1.37	1.41	0.00	0.00	0.00	0.00	0.00

	Thickness of spirotheca (microns)													Septal count												
Spec. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	Spec. No.	1	2	3	4	5	6	7	8	9	10	11	12	13
SBR 10-2	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	14.44	14.44	14.44	14.44	14.44	SBR 10-2	22	27	29	34	38	56	69	72	78	87	98	114	122
SBR 2A	13.32	13.32	13.32	13.32	13.32	13.32	13.32	14.53	14.53	14.53	14.53	0.00	0.00	SBR 2A	25	28	38	55	58	62	88	94	97	102	110	0	0
SBR 10-2	12.22	12.22	12.22	14.67	14.67	14.67	17.11	17.11	17.11	17.11	17.11	17.11	0.00	SBR 10-2	15	22	27	40	44	58	74	82	95	101	123	137	0
SBR 10-2 1	10.61	10.61	10.61	13.26	13.26	13.26	13.26	13.26	13.26	15.92	15.92	15.92	0.00	SBR 10-2 1	16	34	45	45	52	63	52	85	69	51	99	110	0
SBR 10-2 4	18.37	18.37	18.37	15.75	18.37	18.37	18.37	18.37	18.37	18.37	0.00	0.00	0.00	SBR 10-2 4	14	23	30	39	49	57	65	74	86	0	0	0	0
SBR 10-2 10	10.50	10.50	10.50	15.75	15.75	15.75	18.37	18.37	18.37	18.37	0.00	0.00	0.00	SBR 10-2 10	22	28	37	48	58	66	66	72	87	0	0	0	0
SBR 10-2 14	10.50	13.12	13.12	13.12	15.75	15.75	15.75	15.75	15.75	15.75	0.00	0.00	0.00	SBR 10-2 14	12	19	29	38	47	61	72	80	86	92	0	0	0
SBR 10-2 26	13.12	13.12	13.12	15.75	15.75	15.75	15.75	15.75	15.75	15.75	0.00	0.00	0.00	SBR 10-2 26	16	25	28	35	48	51	62	0	0	0	0	0	0
SBR 10-2 27	13.12	13.12	13.12	13.12	13.12	18.37	18.37	18.37	18.37	18.37	0.00	0.00	0.00	SBR 10-2 27	17	18	28	34	43	45	50	57	69	66	0	0	0
SBR 10-2 29	15.75	15.75	15.75	18.37	18.37	18.37	18.37	18.37	18.37	18.37	0.00	0.00	0.00	SBR 10-2 29	16	25	29	37	44	48	67	76	0	0	0	0	0
SBR 10-2 34	13.12	13.12	13.12	15.75	15.75	15.75	15.75	15.75	15.75	15.75	0.00	0.00	0.00	SBR 10-2 34	10	31	33	43	56	63	76	89	0	0	0	0	0

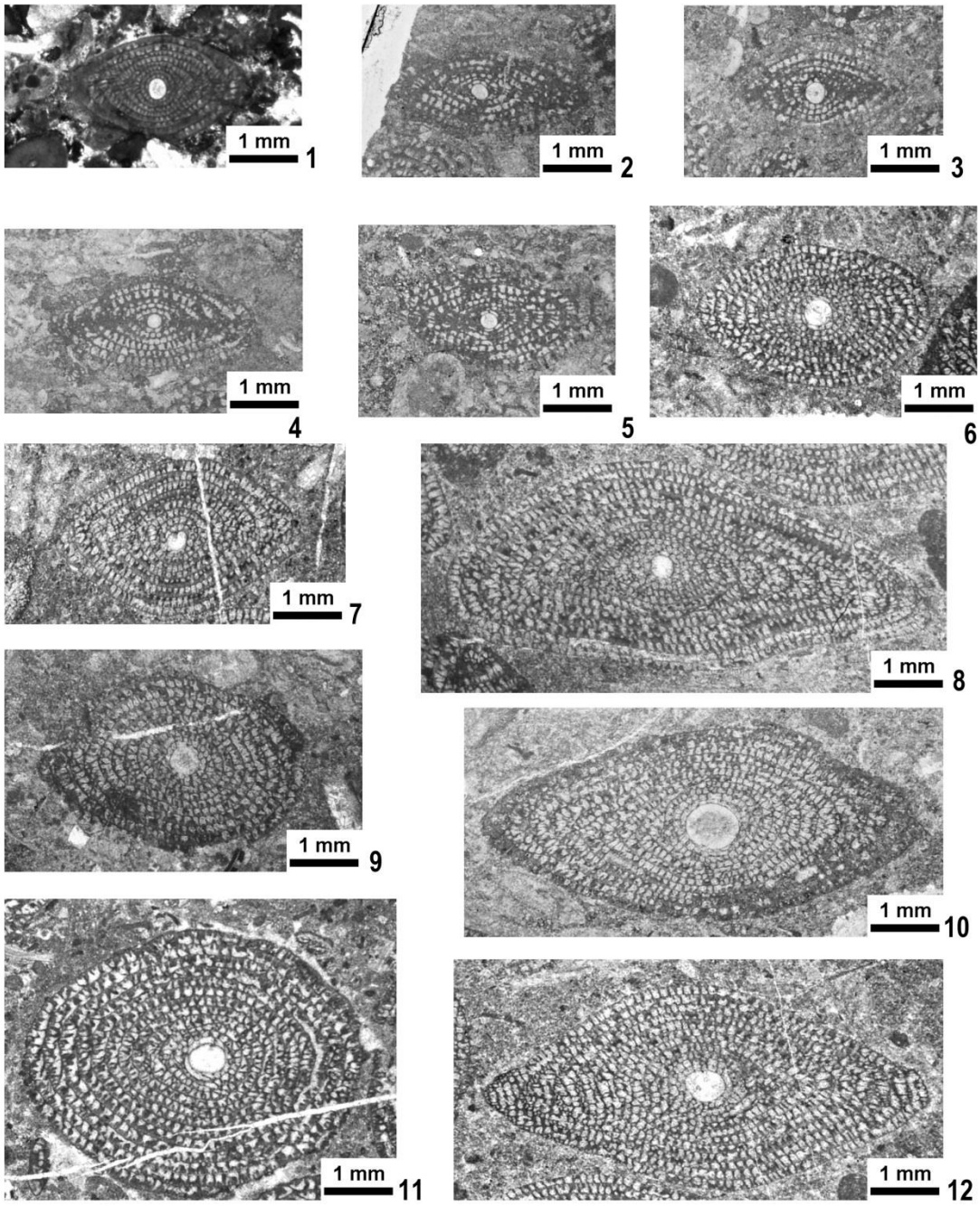

Figure 2.35 Fusulinids from Khao Khwang anf Khao Khad formations. (1-5) *Neoschwagerina megasphaerica* (1) Axial section, SBR 13D-2. (2) Axial section, SBR 15D-7. (3) Axial section, SBR 15D-8. (4) Axial section, SBR 15D-4. (5) Axial section, SBR-15D-12. (6-12) *Colania douvillei* (6) Axial section, SBR 10-2. (7) Axial section, SBR10-2 34. (8) Axial section, SBR 10-2 5. (9) Axial section, SBR-10-2 26. (10) Axial section, SBR 10-2 1 (11) Axial section, SBR2A-6 (12) Axial section, SBR10-2 5.

Subfamily Lepidolininae A. D. Miklukho-Maklay, 1958

Genus *Lepidolina* Lee, 1933 emend. Ozawa, 1970a

Lepidolina shiraiwensis (Ozawa, 1925)

Figure 2.36 (pics 3-8); Figure 2.37 (pics 1)

Yabeina shiraiwensis Ozawa, 1925, p. 63, 64, pl. 2, figs. 2b, 5c, pl. 10, figs. 1, 2.

Yabeina shiraiwensis (Ozawa). Morikawa, 1960, p. 296, 297, pl. 53, figs. 1-9.

Colania kotsuboensis Choi, 1973, p. 63, 64, pl. 16, figs. 1, 6, 7, 10.

Lepidolina shiraiwensis (Ozawa). Kobayashi et al., 2008, figs. 9.8-9.13.

Description: Size of shell is moderate with subspherical to spherical of proloculus. The mature shell has 11 to 13 volutions. The form ratio 1.36 to 1.84. The diameter of proloculus devides from 0.09 to 0.72 mm. The spirothecal wall is thick and well developed secondary transverse septula.

Materials: SBR 2A-5, SBR 2A -6, SBR 11B-27, SBR 38I-7, SBR 38I-13

Age: Latest Wordian to Capitanian (Kobayashi et al., 2009)

Table 2.15 Measurement of *Lepidolina shiraiwensis*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Thicness of Proloculus wall (microns)	H.L. (mm)													
						Spec. No.	1	2	3	4	5	6	7	8	9	10	11	12	13
SBR 2A-5	6.04	3.28	1.84	0.55	16.95	SBR 2A-5	0.41	0.60	0.75	0.93	1.20	1.44	1.80	2.06	2.31	2.74	2.97	0.00	0.00
SBR 2A -6	5.83	3.27	1.78	0.72	22.00	SBR 2A -6	0.59	0.78	0.91	1.09	1.39	1.70	1.98	2.32	2.74	2.98	0.00	0.00	0.00
SBR 11B-27	6.20	3.43	1.81	0.30	17.24	SBR 11B-2	0.28	0.46	0.72	0.97	1.25	1.53	1.85	2.20	2.56	2.93	0.00	0.00	0.00
SBR 38I-7	5.04	3.71	1.36	0.22	23.62	SBR 38I-7	0.31	0.43	0.54	0.67	0.81	0.97	1.14	1.36	1.61	1.83	2.04	2.29	2.50
SBR 38I-13	4.05	2.55	1.59	0.09	11.90	SBR 38I-13	0.20	0.35	0.42	0.53	0.67	0.85	1.03	1.20	1.43	1.65	1.82	2.03	0.00

R.V (mm)														H.L/R.V											
Spec. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	Spec. No.	1	2	3	4	5	6	7	8	9	10	11	12	13
SBR 2A-5	0.38	0.46	0.57	0.70	0.82	0.91	1.06	1.23	1.38	1.52	1.68	0.00	0.00	SBR 2A-5	1.09	1.29	1.32	1.33	1.46	1.57	1.70	1.67	1.66	1.80	1.77	0.00	0.00
SBR 2A -6	0.45	0.55	0.70	0.82	0.94	1.08	1.22	1.34	1.46	1.59	0.00	0.00	0.00	SBR 2A -6	1.31	1.41	1.31	1.32	1.48	1.58	1.63	1.74	1.88	1.87	0.00	0.00	0.00
SBR 11B-27	0.29	0.43	0.58	0.70	0.86	1.04	1.24	1.43	1.63	1.90	0.00	0.00	0.00	SBR 11B-27	0.97	1.08	1.24	1.38	1.46	1.47	1.49	1.53	1.57	1.54	0.00	0.00	0.00
SBR 38I-7	0.30	0.38	0.45	0.55	0.64	0.80	0.92	1.08	1.25	1.42	1.61	1.78	2.01	SBR 38I-7	1.06	1.12	1.18	1.23	1.26	1.22	1.24	1.26	1.29	1.29	1.26	1.29	1.24
SBR 38I-13	0.17	0.21	0.29	0.36	0.46	0.56	0.65	0.78	0.91	1.05	1.18	1.30	0.00	SBR 38I-13	1.20	1.68	1.47	1.46	1.45	1.51	1.58	1.54	1.57	1.57	1.54	1.56	0.00

Thickness of spirotheca (microns)														Septal count													
Spec. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	Spec. No.	1	2	3	4	5	6	7	8	9	10	11	12	13
SBR 2A-5	12.11	12.11	12.11	12.11	13.32	13.32	13.32	13.32	12.11	12.11	13.32	0.00	0.00	SBR 2A-5	23	29	43	44	59	63	71	80	101	104	127	0	0
SBR 2A -6	12.22	12.22	12.22	12.22	12.22	12.22	13.94	13.94	13.94	13.94	0.00	0.00	0.00	SBR 2A -6	22	38	49	51	65	65	88	86	80	102	0	0	0
SBR 11B-27	14.04	14.04	14.04	14.04	14.04	12.32	12.32	12.32	12.32	12.32	0.00	0.00	0.00	SBR 11B-27	13	28	43	51	54	71	41	79	0	0	0	0	0
SBR 38I-7	18.37	18.37	18.37	21.00	21.00	21.00	18.37	18.37	18.37	21.00	21.00	0.00	0.00	SBR 38I-7	25	39	48	57	66	74	86	94	96	101	116	0	0
SBR 38I-13	16.67	16.67	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	0.00	0.00	0.00	SBR 38I-13	22	28	35	48	54	58	60	76	80	0	0	0	0

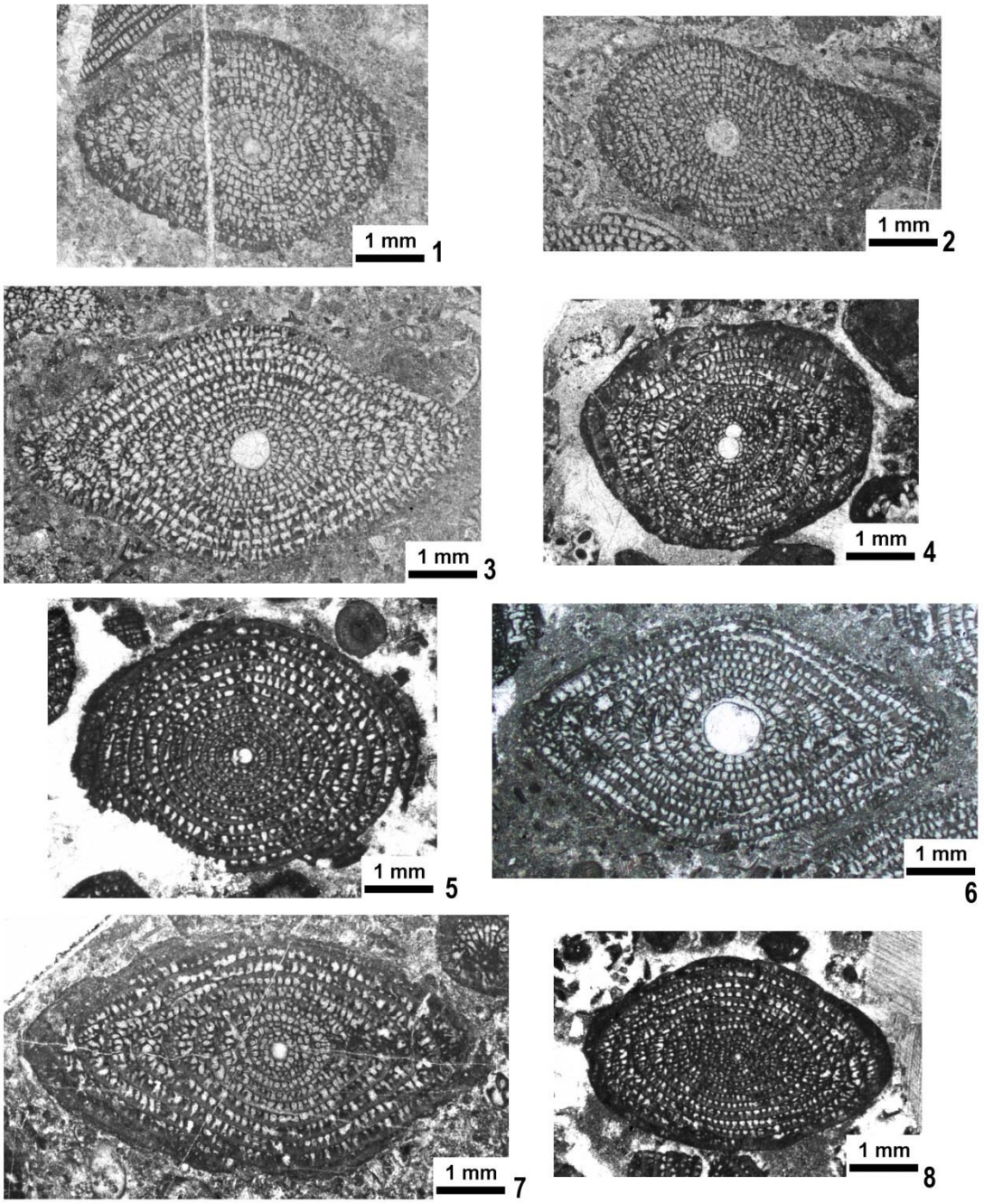

Figure 2.36 Fusulinids from Khao Khwang and Khao Khad formations. (1-2) *Colania douvillei* (1) Axial section, SBR 10-2 4. (2) Axial section, SBR 10-2 10. (3-8) *Lepidolina shiraiwensi* (3) Axial section, SBR2A-5. (4) Axial section, SBR38I-4. (5) Axial section, SBR38-7 (6) Axial section, SBR2A-6. (7) Axial section, SBR11B-27. (8) Axial section, SBR38I-13.

Subfamily Sumatrininae Silvestri, 1933

Genus *Presumatrina* Tumanskaya, 1950

Presumatrina ciryi Kobayashi and Altiner, 2010

Figure 2.37 (pics 2, 3)

Presumatrina ciryi Kobayashi and Altiner, 2010, pl. 3, figs 1-22.

Description: Test moderate. Ellipsoidal shape with broadly rounded poles. Mature of 2 specimens about 2.39 to 4.97 mm in length, 1.65 to 2.30 in width and 1.45 to 2.16 in form ratio. Proloculus is spherical to subspherical and diameter present from 0.14 to 0.16 mm.Wall thin and comprises of tectum with septa thin.

Materials: SBR 25, SBR 25B-1

Age: Lower Murgabian

Table 2.16 Measurement of *Presumatrina ciryi*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Thicness of Proloculus wall (microns)	H.L. (mm)										
						Spec. No.	1	2	3	4	5	6	7	8	9	10
SBR 25	2.39	1.65	1.45	0.16	18.37	SBR 25	0.18	0.27	0.38	0.57	0.79	0.95	1.19	0.00	0.00	0.00
SBR 25B-1	4.97	2.30	2.16	0.14	18.37	SBR 25B-1	0.18	0.44	0.64	0.84	1.06	1.21	1.66	1.87	2.09	2.32
R.V (mm)																
Spec. No.	1	2	3	4	5	6	7	8	9	10						
SBR 25	0.19	0.25	0.30	0.39	0.49	0.61	0.73	0.00	0.00	0.00						
SBR 25B-1	0.15	0.19	0.27	0.36	0.57	0.69	0.93	1.03	0.00	0.00						
H.L/R.V																
Spec. No.	1	2	3	4	5	6	7	8	9	10						
SBR 25	0.94	1.07	1.25	1.48	1.60	1.56	1.63	0.00	0.00	0.00						
SBR 25B-1	1.18	2.38	2.39	2.33	1.85	1.77	1.77	1.82	0.00	0.00						
Thickness of spirotheca (microns)																
Spec. No.	1	2	3	4	5	6	7	8	9	10						
SBR 25	18.37	18.37	18.37	18.37	18.37	0.00	0.00	0.00	0.00	0.00						
SBR 25B-1	18.37	18.37	18.37	23.62	23.62	23.62	23.62	23.62	0.00	0.00						
Septal count																
Spec. No.	1	2	3	4	5	6	7	8	9	10						
SBR 25	11	0	22	30	0	0	0	0	0	0						
SBR 25B-1	10	18	30	38	43	58	61	0	0	0						

Genus *Sumatrina* Volz, 1904

Sumatrina annae, 1904

Figure 2.37(pics 4-8)

Sumatrina annae Volz, 1904, pp. 98-100, text-figs. 27-31.

Neoschwagerina (*Sumatrina*) *annae* Deprat, 1912, pp. 56-57, pl. 5, figs. 1-3, text-figs. 30a-h.

Sumatrina annae Sheng, 1963, pp. 245-246, pl. 36, figs. 1-11.

Sumatrina annae Toriyama and Pitakpaivan, 1973, pp. 57-60, pl. 6, figs. 14-25.

Sumatrina annae Toriyama and Kanmera, 1977, pp. 14-17, pl. 3, figs. 18-28.

Description: Shell is small size with elongate fusiform in shape, with almost straight axis of coiling, gently convex to straight lateral slopes, and bluntly pointed poles. A length of this specimen is 5.47 mm and a width is 2.03 mm, giving a form ratio of 2.70. Subspherical present in first and second volutions and axis becomes extended rapidly from the third volution. Ratios of half length to radius vector of the first to eighth volutions in one specimen 0.22, 0.25, 0.37, 0.48, 0.61, 0.73, 0.88 and 1.03, respectively. Shape of proloculus is subspherical that have 0.19 mm in diameter. Spirotheca is very thin, comprising of a single dense layer. The thickness of spirotheca of the first to ninth volutions about 10 microns. Type of septa show in pendant-shapped and axial septula well developed. Average septal count of fifth to ninth volutions in one specimen are 31, 47, 58, 70 and 85, respectively.

Materials: SBR 12B-8

Age: Wordian to Upper Capitanian (Toriyama and Kanmera, 1977)

Sumatrina cf. *longissima* Deprat, 1914

Figure 2.37 (pics 9)

Sumatrina longissima Deprat, 1914, p. 36, pl. 5, figs. 1-6.

Sumatrina longissimi Sheng, 1963, pp. 246-247, pl. 36, figs. 18-19.

Description: Medium of shell size, elongately and cylindrical with pole bluntly pointed. Mature shell having 8 volutions about 7.71 mm long and 1.74 mm wide, with form ratio ranging 4.43. Ratio of half length and radius vector of one specimen are 4.58, 4.44, 4.43, 3.75, 3.82, 4.20 and 4.17, respectively. Shape of proloculus is spherical to subspherical, diameter is 0.14 mm and have thickness of 18 microns. Spirotheca consist of a single compact layer with 10 microns. Thick septa and plane.

Materials: SBR 12C-11

Age: Capitanian (Ozawa, 1970)

Table 2.17 Measurement of *Sumatrina annae*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Thicness of Proloculus wall (microns)				
SBR 12B-8	5.47	2.03	2.70	0.19	18.18				
H.L. (mm)									
Spec. No.	1	2	3	4	5	6	7	8	9
SBR 12B-8	0.54	0.77	1.18	1.45	1.66	2.10	2.38	2.73	3.11
R.V (mm)									
Spec. No.	1	2	3	4	5	6	7	8	9
SBR 12B-8	0.22	0.25	0.37	0.48	0.61	0.73	0.88	1.03	0.00
H.L/R.V									
Spec. No.	1	2	3	4	5	6	7	8	9
SBR 12B-8	2.45	3.12	3.23	3.04	2.74	2.87	2.71	2.66	0.00
Thickness of spirotheca (microns)									
Spec. No.	1	2	3	4	5	6	7	8	9
SBR 12B-8	10.39	10.39	10.39	10.39	10.39	10.39	10.39	10.39	10.39
Septal count									
Spec. No.	1	2	3	4	5	6	7	8	9
SBR 12B-8	0	0	0	0	31	47	58	70	85

Table 2.18 Measurement of *Sumatrina* cf. *longissima*

Spec. No.	L (mm)	W (mm)	Form ratio	Diameter of Proloculus (mm)	Thicness of Proloculus wall (microns)			
SBR 12C-11	7.71	1.74	4.43	0.14	18.18			
H.L. (mm)								
Spec. No.	1	2	3	4	5	6	7	8
SBR 12C-11	0.63	0.98	1.30	1.55	2.06	2.81	3.44	3.92
R.V (mm)								
Spec. No.	1	2	3	4	5	6	7	8
SBR 12C-11	0.14	0.22	0.29	0.41	0.54	0.67	0.83	0.00
H.L/R.V								
Spec. No.	1	2	3	4	5	6	7	8
SBR 12C-11	4.58	4.44	4.43	3.75	3.82	4.20	4.17	0.00
Thickness of spirotheca (microns)								
Spec. No.	1	2	3	4	5	6	7	8
SBR 12C-11	10.39	10.39	10.39	10.39	10.39	10.39	10.39	10.39
Septal count								
Spec. No.	1	2	3	4	5	6	7	8
SBR 12C-11	0	0	0	0	0	77	82	105

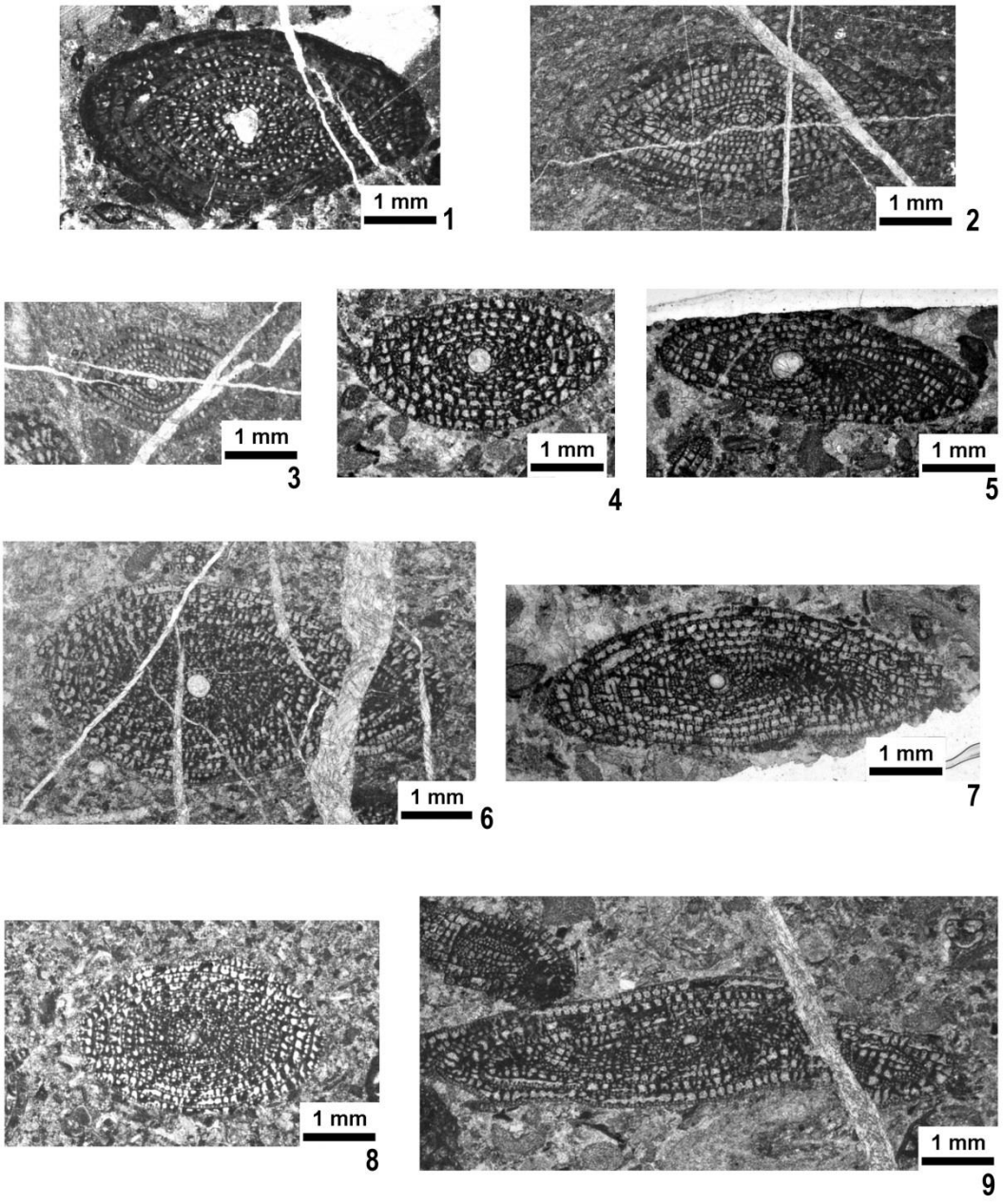

Figure 2.37 Fusulinids from Khao Khwang and Khao Khad formations. (1) *Lepidolina shiraiwensi,* Axial section, SBR38I-12. (2-3) *Presumatrina ciryi* (2) Axial section, SBR25 B. (3) Axial section, SBR25B-1. (4-8) *Sumatrina annae* (4) Axial section, SBR12A-1. (5) Axial section, SBR12B-7. (6) Sagittal section, SBR29A-3. (7) Axial section, SBR12B-8. (8) Sagittal section, SBR28E-18. (9) *Sumatrina* cf. *longissimi*, Axial section, SBR 12C-11

CHAPTER 3
INTERPRETATION

3.1 Fusulinacean Biostratigraphy

From systematic paleontology, fusulinids in study area can be identified and classified to 5 families, 11 subfamilies, 15 genera and 15 species including, *Robustoschwagerina, Yangchienia*, *Parafusulina loeyensis*, *Parafusulina gigantea*, *Laosella edoensis*, *Pseudofusulina*, *Chusenella chihsiaensis*, *Chusenella* (*Chusenella*) *shengi*, *Verbeekina verbeeki*, *Misellina*, *Pseudodoliolina*, *Thailandina buravasi*, *Neoschwagerina megasphaerica*, *Colania douvillei*, *Lepidolina shiraiwensis*, *Presumatrina ciryi*, *Sumatrina annae*, and *Sumatrina* cf. *longissima*.

Fusulinids from Khao Khwang Formation are composed of *Yangchienia*, *Parafusulina loeyensis*, *Parafusulina gigantea*, *Chusenella chihsiaensis*, *Verbeekina verbeeki*, *Colania douvillei*, *Lepidolina shiraiwensis* and *Sumatrina annae*. Whereas fusulinids from Khao Khad Formation consist of *Robustoschwagerina, Yangchienia*, *Parafusulina loeyensis*, *Parafusulina gigantea*, *Laosella edoensis*, *Pseudofusulina*, *Chusenella chihsiaensis*, *Chusenella* (*Chusenella*) *shengi*, *Verbeekina verbeeki*, *Misellina*, *Pseudodoliolina*, *Thailandina buravasi*, *Neoschwagerina megasphaerica*, *Colania douvillei*, *Lepidolina shiraiwensis*, *Presumatrina ciryi*, *Sumatrina annae* and *Sumatrina* cf. *longissima*. Fusulinid distribution of Khao Khwang and Khao Khad formations can be summarized in Table 3.1.

In study area, fusulinids from Khao Khwang and Khao Khad formations have similarities except *Robustoschwagerina* can be observed only in Khao Khad Formation. Age of carbonate rock indicated by fusulinid can be implied to the starting time of carbonate buildup. The results show that carbonate rocks of Khao Khad Formation in Saraburi province were deposited first during Early Permian (Sakmarian – Yakhtashian) while the ones in Khao Khwang Formation were started during Middle Permian (Murgabian).

Based on fusulinid and geologic age, fusulinacean biostratigraphy of Khao Khwang and Khao Khad formations in Saraburi province was concluded as follow:-

In Early Permian (Sakmarian-Yakhtashian), carbonate rocks of Khao Khad Formation were deposited in this time based on *Robustoschwagerina* age, while in Khao Khwang Formation, early Permian carbonate rocks were not observed.

In Middle Permian (Murgabian), Khao Khwang and Khao Khad formations both deposited in this age. Fusulinids from Khao Khwang Formation are composed *of Verbeekina verbeeki*, *Parafusulina gigantea* and *Chusenella*. While fusulinids from Khao Khad Formation consist of *Presumatrina ciryi*, *Thailandina buravasi* and *Chusenella*.

In late Middle Permian (Midian), the similarity of fusulinid assemblage from Khao Khwang and Khao Khad formations have been observed. Fusulinids from Khao Khwang Formation consist of *Sumatrina* cf. *longissima*, *Verbeekina verbeeki*, *Neoschwagerina megasphaerica*, *Colania douvillei*, *Lepidolina shiraiwensis* and *Sumatrina annae*, while the ones from Khao Khad Formation are composed of *Colania douvillei*, *Verbeekina verbeeki*, *Sumatrina annae* and *Lepidolina shiraiwensis*.

Fusulinid comparison (Figure 3.1) and fusulinacean biostratigraphy (Figure 3.2) shows that carbonate rocks of Khao Khwang and Khao Khad formations were deposited at the same time at least in late Middle Permian (Murgabian-Midian).

Table 3.1 Fusulinid distribution of Khao Khwang and Khao Khad formations, Saraburi province.

	Fusulinids	*Robustoschwagerina*	*Parafusulina loeyensis*	*Parafusulina gigantea*	*Laosella edoensis*	*Pseudofusulina*	*Yangchienia*	*Chusenella*	*Chusenella chihsiaensis*	*Chusenella (Chusenella) shengi*	*Presumatrina ciryi*	*Pseudodoliolina*	*Thailandina buravasi*	*Neoschwagerina megasphaerica*	*Verbeekina verbeeki*	*Lepidolina shiraiwensis*	*Colania douvillei*	*Sumatrina annae*	*Sumatrina cf. longissima*
KKD	SBR 12							■							■	■		■	■
	SBR 28		■	■	■	■		■	■	■								■	
	SBR 29																■	■	
	SBR 23																■		
	SBR 24																■		
	SBR 18																■		
	SBR 21																■		
	SBR 9														■		■		
	SBR 20														■		■		
	SBR 13													■			■		
	SBR 25										■				■		■		
	SBR 15			■										■	■		■		
	SBR 10														■	■	■		
	SBR 11														■	■	■		
	SBR 22			■	■					■			■						
	SBR 19				■		■	■			■				■				
	SBR 39	■																	
KKG	SBR 34																	■	
	SBR 6																■		
	SBR 33																■		
	SBR 2							■								■	■		
	SBR 31														■		■		
	SBR 3						■	■							■	■	■		
	SBR 38							■				■				■			
	SBR 7					■	■	■	■										
	SBR 30		■	■											■				
	SBR 4						■	■											

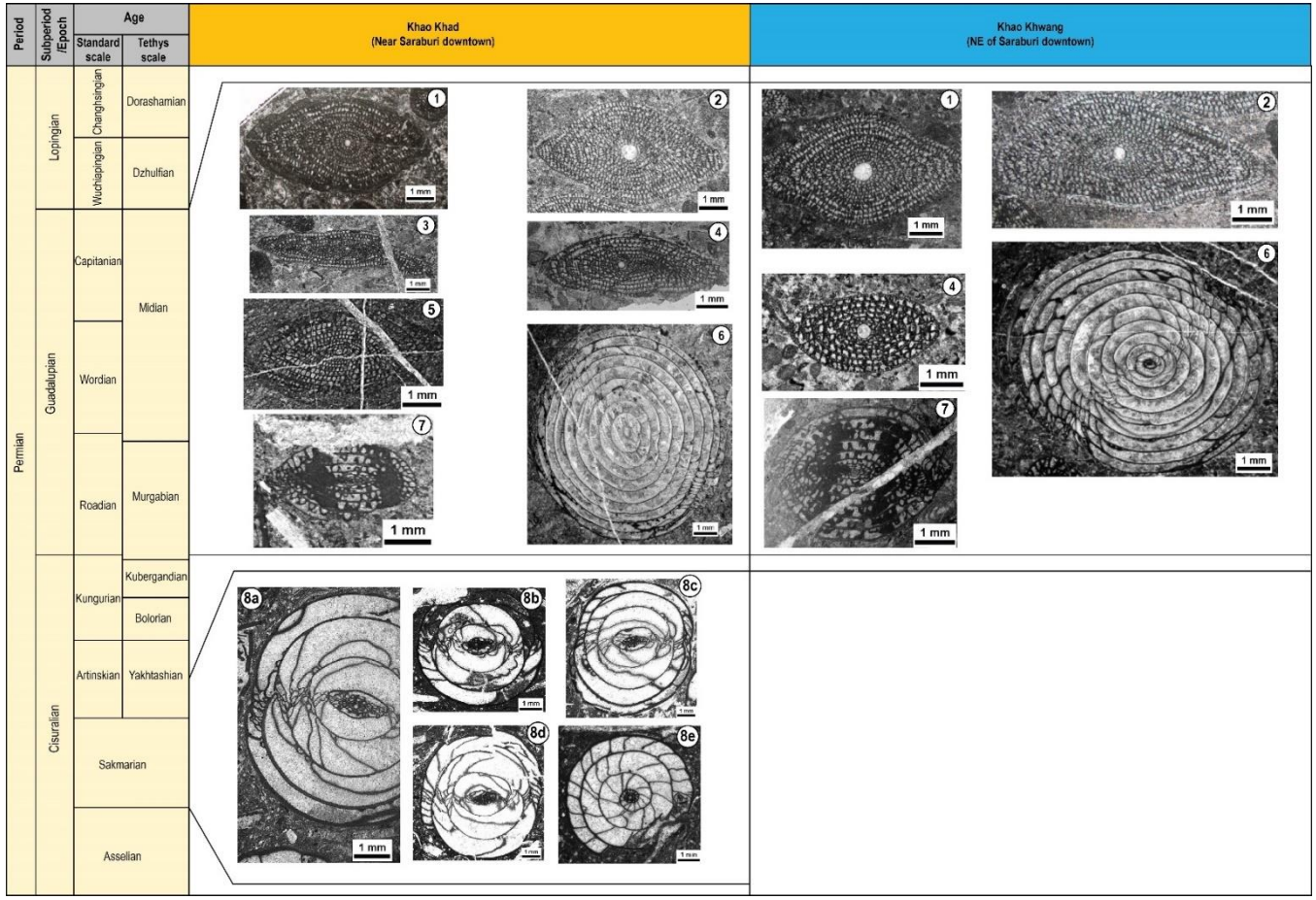

Figure 3.1 Fusulind comparison of Khao Khwang and Khao khad formations, Saraburi province. 1) *Lepidolina shiraiwensis*, 2) *Colania douvillei*, 3) *Sumatrina* cf. *longissimi*, 4) *Sumatrina annae*, 5) *Presumatrina ciryi, 6) Verbeekina verbeeki*, 7) *Chusenella*, 8a-8e) *Robustoschwagerina*.

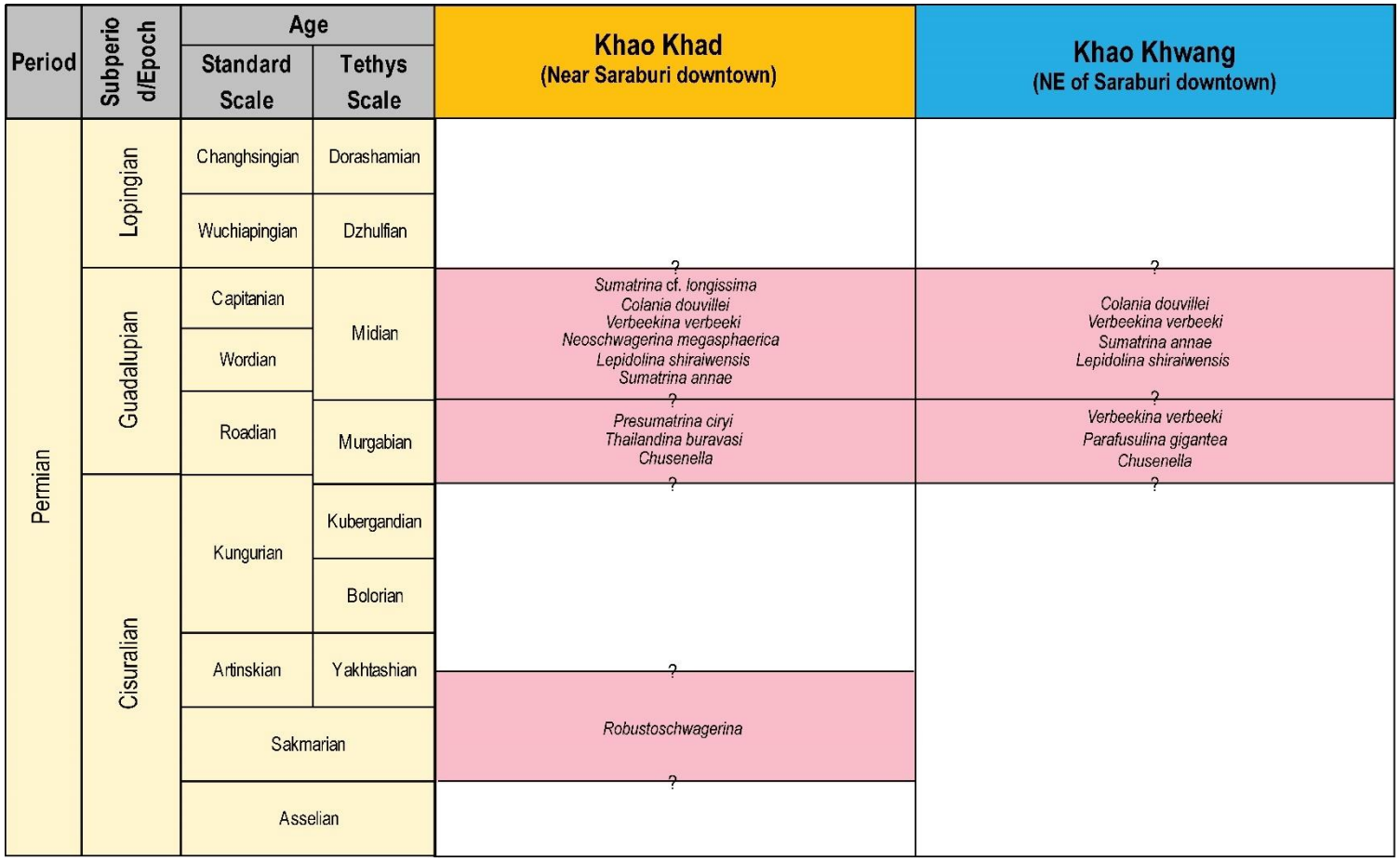

Figure 3.2 Fusulinacean biostratigraphy of Khao Khwang and Khao Khad formations, Saraburi province. Khao Khwang formation oldest deposited in Murgabian and youngest deposited in Midian. While Khao Khad formation oldest deposited in Sakmarian-Yakhtashian and youngest deposited in Midian. These formations deposited in the same time at least in Murgabian-Midian.

3.2 Depositional Environment

Based on lithology, carbonate petrography and palaeontology, carbonate rocks in the study area can be interpreted the depositional environments. Carbonate rocks in study area indicated that deposited in shallow marine environments to slope deposits. The classification of depositional environments will be referred to Flügel (2010). Carbonate rocks in study area were deposited in various paleoenvironments including tidal, lagoon, outer shelf and slope. Depositional environment of all ages was mentioned as follow:-

Sakmarian – Yakhtashian

The rock of Sakmarian – Yakhtashian in study area was found only from outcrop SBR 39 of Khao Khad Formation. Rock type of sample SBR 39 is bioclastic rudstone. The most of bioclastic grains are fusulinids (*Robustoscwagerina* and some *Parafusulina*) and sparry calcite. It shows abandant of fusulinid fauna.

Abandant of fusulinid fauna indicated that rock sample SBR 39 was deposited at outer shelf which connected with open marine. The depositional environment model of Sakmarian-Yakhtashian rock is presented in Figure 3.3.

Murgabian

The Murgabian rocks in study area consist of carbonate rocks from SBR 30, SBR4 and SBR 7 of Khao Khwang Formation and carbonate rocks from SBR 19 and SBR 22 of Khao Khad Formation.

Rock type of sample SBR 19 consists of bioclastic rudstone with fusulinids (*Presumatrina ciryi* and *Chusenella*) and sparry calcite. It indicates to outer shelf environment. And rock type of sample SBR 22 consists of bioclastic rudstone. The bioclastic grains are composed of fusulinids and crinoid fragments. It indicates to slope deposit.

Rock type of sample SBR 30 consists of bioclastic rudstone with fusulinids (*Parafusulina gigantea* and *Parafusulina loeyensis*) and sparry calcite. It indicates to outer shelf environment. Rock type of sample SBR 7 consists of bioclastic rudstone with fusulinids (*Pseudofusulina* and *Yangchienia*) and sparry calcite. It indicates to outer

shelf environment. Rock type of sample SBR 4 is composed of calcimudstone with some fusulinids (*Yangchienia*). It indicates to lagoon environment.

In Middle Permian (Murgabian), Khao Khad Formation deposited in outer shelf and slope environments, while Khao Khwang Formation deposited in lagoon and outer shelf environments. The depositional environment model of Murgabian is presented in Figure 3.4.

Midian

The Midian rocks in study area consist of carbonate rocks of SBR 2, 3, 6, 31, 33 and 38 from Khao Khwang Formation and carbonate rocks of SBR 9, 10, 11, 12, 13, 15, 18, 20, 21, 23 and 28 from Khao Khad Formation.

Samples of SBR 3 and 33 from Khao Khwang Formation and the one SBR 18 from Khao Khad Formation consist of limestone with bird's-eye structure and laminated limestone. It indicates intertidal environment.

Samples from SBR 31 and 33 of Khao Khwang Formation and SBR 18 of Khao Khad Formation consist of calcimudstone. It contains only carbonate mud and shows low diversity of fauna. It indicates lagoon environment.

Rock type of samples SBR 2, 6, 31, 38 from Khao Khwang Formation and SBR 9, 10, 11, 12, 13, 15, 20, 28 from Khao Khad Formation consists mainly of bioclastic rudstone and bioclastic packstone. Most bioclastic grains are fusulinids, smaller foraminifera. They show high diversity of fauna. Therefore, they indicate outer shelf environment.

Rock type of samples SBR 21 and 23 from Khao Khad Formation consists of bioclastic rudstone and bioclastic wackestone respectively. The bioclastic grains contain a lot of crinoid fragments and intraclasts. They indicated slope deposit. The depositional environment model of Midian is presented in Figure 3.5.

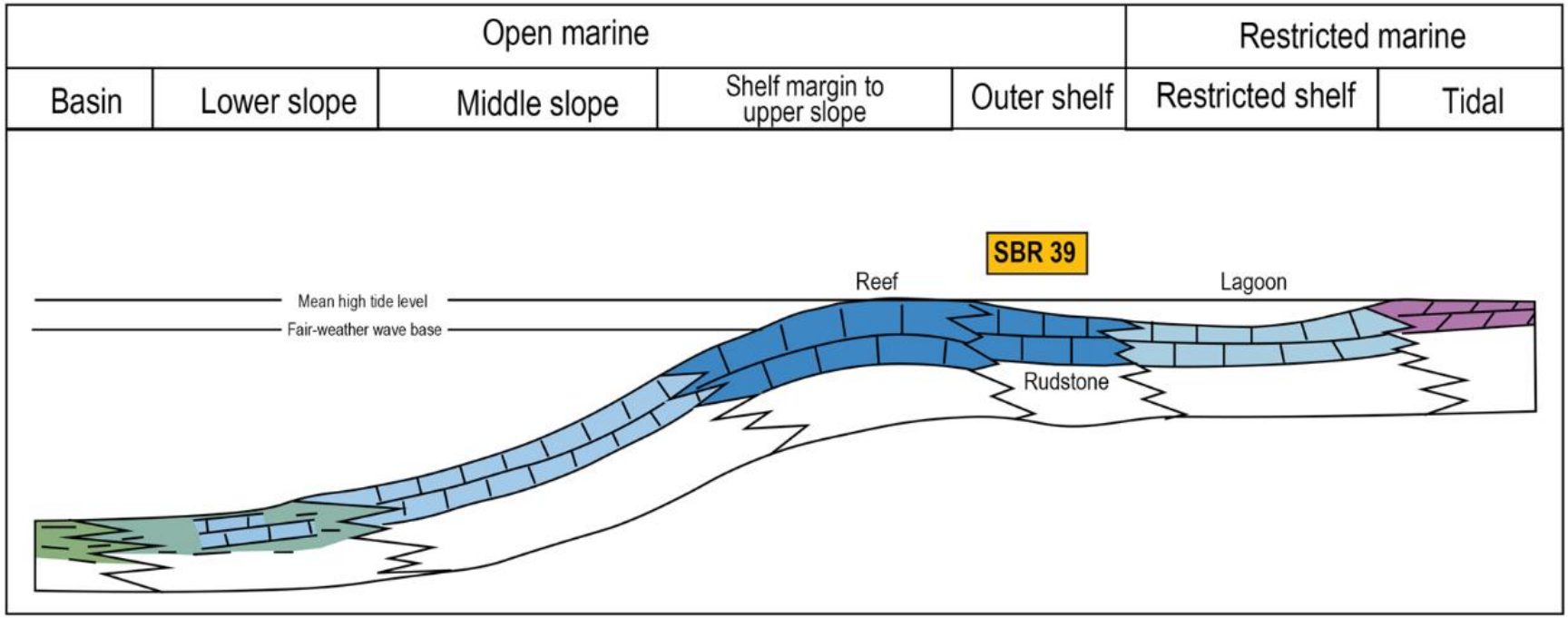

Figure 3.3 Depositional environment model of Sakmarian – Yakhtashian. Limestone from SBR 39 represent the rock in this age and it deposited at outer shelf.

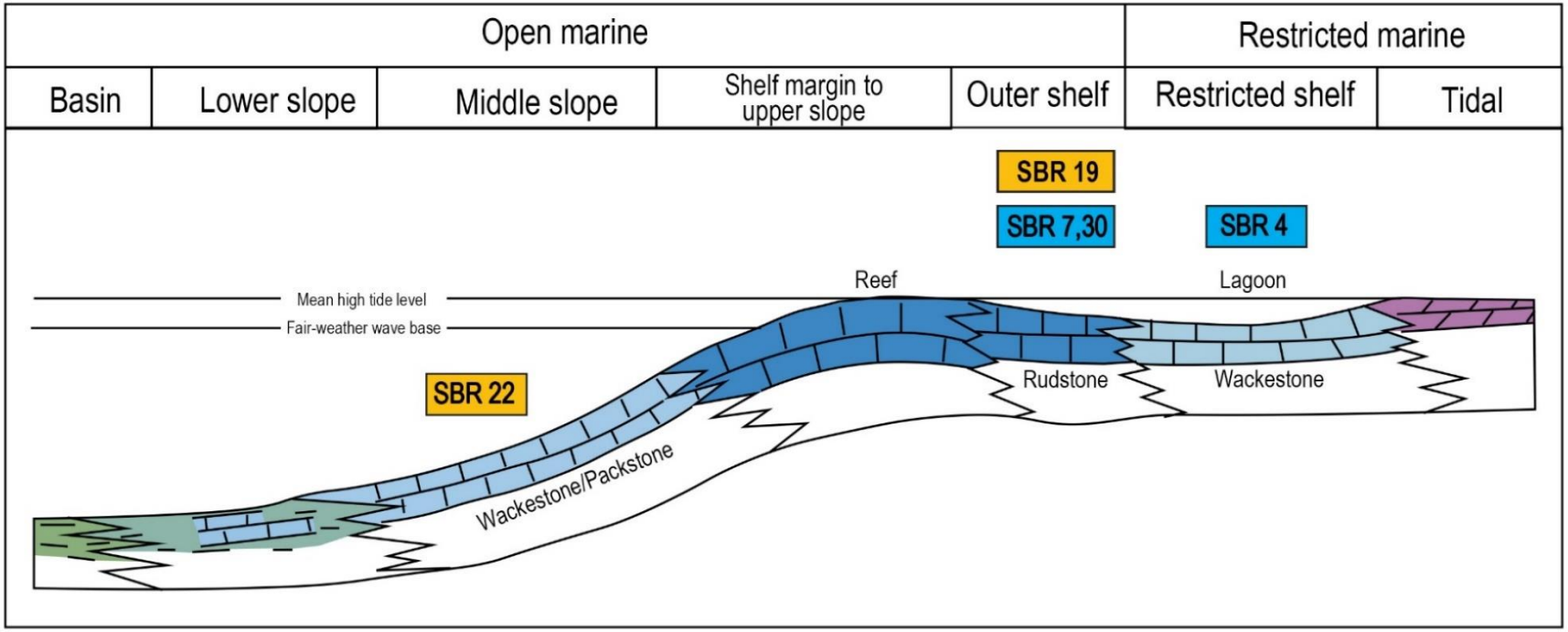

Figure 3.4 Depositional environment model of Murgabian. Khao Khad formation deposited in outer shelf and slope. While Khao Khwang formation deposited in lagoon and outer shelf environment.

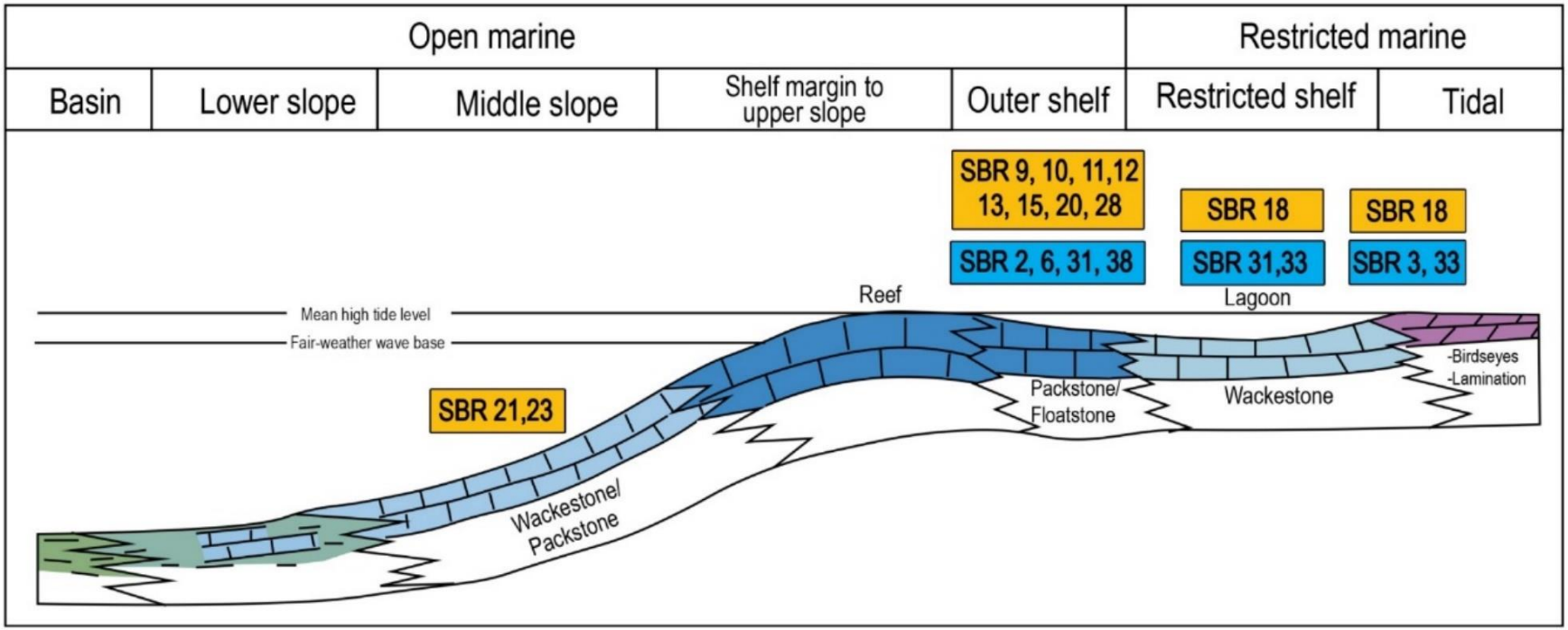

Figure 3.5 Depositional environment model of Midian. Khao Khwang formation deposited in tidal, lagoon and outer shelf environments. While Khao Khad formation deposited in tidal, lagoon, outer shelf and slope environments.

CHAPTER 4
CONCLUSIONS AND DISCUSSIONS

1. Khao Khwang and Khao Khad formations of Saraburi Group were exposed in Saraburi province and adjacent areas of central Thailand. They predominantly consist of light to dark grey, thin to massive limestones with nodular cherts and interbedded with shale in some parts.

2. Fusulinids in the study area belong to 5 families, 11 sub families, 15 genera and 15 spices, including, *Robustoschwagerina, Yangchienia, Parafusulina loeyensis, Parafusulina gigantea, Laosella edoensis, Pseudofusulina, Chusenella chihsiaensis, Chusenella* (*Chusenella*) *shengi, Verbeekina verbeeki, Misellina, Pseudodoliolina, Thailandina buravasi, Neoschwagerina megasphaerica, Colania douvillei, Lepidolina shiraiwensis, Presumatrina ciryi, Sumatrina annae* and *Sumatrina* cf. *longissima.*

3. Geological age of carbonate rocks determined by fusulinids can be explained the development of carbonate Khao Khwang and Khao Khad formations. It shows that Khao Khad Formation were first started during Early Permian age (Sakmarian-Yakhtashian) while the ones of Khao Khwang Formation were developed during late Middle Permian (Murgabian - Midian) in Saraburi area.

4. Depositional environment of Khao Khwang and Khao Khad formations can be explained by subdivided to 3 age as follow.

a. In Sakmarian-Yakhtashian time, Khao Khad Formation was deposited in outer shelf environment.

b. In Murgabian time, Khao Khwang Formation was deposited in restricted lagoon and outer shelf. Khao Khad Formation deposited in slope and open marine outer shelf environment.

c. In Midian time, Khao Khwang Formation was deposited in tidal, lagoon and outer shelf environment. Khao Khad Formation was deposited in tidal, lagoon, outer shelf and slope environment.

5. Based on fusulinid biostratigraphy and depositional environment studies, it can be concluded that the two formations were deposited in different environments, different locations at the same time at least during late Middle Permian (Murgabian – Midian).

6. Relationship of Khao Khwang and Khao Khad formations have been considered as contemporaneous facies and they are not simple superposition relationship as considered before. However, the relationship of all formations in Saraburi Group should be studied in details.

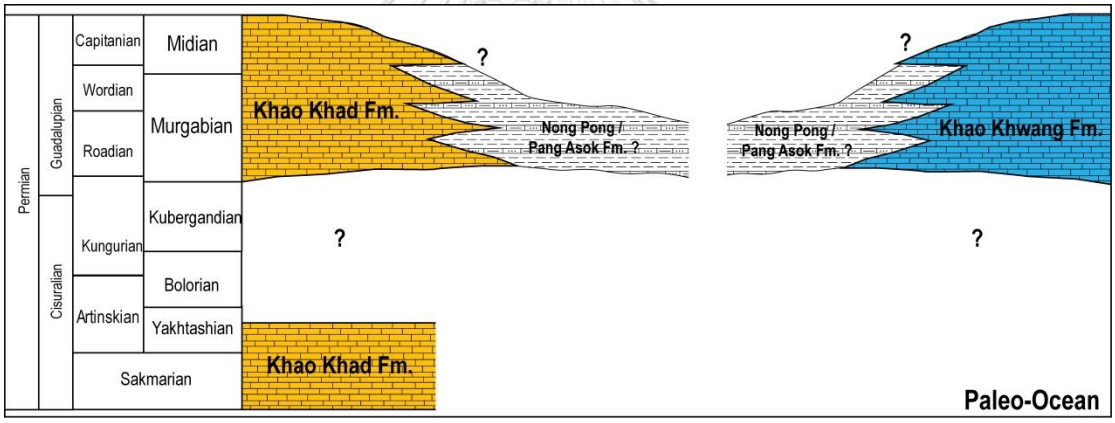

Figure 4.1 Model shows relationship of Khao Khwang and Khao Khad formations which were occurred in the same period of time at least during Murgabian – Midian stages.

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