TAXONOMY OF PERMIAN OSTRACODS FROM CENTRAL, NORTHEASTERN, AND WESTREN THAILAND: IMPLICATION FOR PALEOENVIRONMENT AND PALEOBIOGEOGRAPHY

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อนุกรมวิธานออสตราคอดยุคเพอร์เมียนจากภาคกลางภาคตะวันออกเฉียงเหนือ และภาคตะวันตกของประเทศไทย: การแสดงสภาพแวดล้อมบรรพกาล และชีวภูมิศาสตร์บรรพกาล

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Suranaree University of Technology has approved this thesis submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

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อานิสงส์ จิตนารินทร์ : อนุกรมวิธานออสตราคอดยุคเพอร์เมียนจากภาคกลาง ภาคตะวันออกเฉียงเหนือและภาคตะวันตกของประเทศไทย: การแสดงสภาพแวดล้อมบรรพกาลและชีวภูมิศาสตร์บรรพกาล (TAXONOMY OF PERMIAN OSTRACODS FROM CENTRAL, NORTHEASTERN, AND WESTERN THAILAND: IMPLICATION FOR PALEOENVIRONMENT AND PALEOBIOGEOGRAPHY) อาจารย์ที่ปรึกษา : ผู้ช่วยศาสตราจารย์ ดร.ณัฐวุฒิ ธานี, 322 หน้า.

จากการสำรวจหน้าตัดหิน 15 แห่งและจุดสำรวจ 2 แห่ง ในหินปูนอายุเพอร์เมียนตอนต้นถึงช่วงปลายของเพอร์เมียนตอนกลาง ในพื้นที่เลย เพชรบูรณ์ นครสวรรค์-ลพบุรี และกาญจนบุรี ตัวอย่างหินปูนที่เก็บมาถูกนำมาละลายโดยวิธีฮอทอะซิโตไลซิส ซึ่งสามารถแยกออสตราคอดจำนวนมากออกมาได้ ออสตราคอดมี 196 สปีชีส์ 41 สกุล ในจำนวนนี้ 29 สปีชีส์ถูกพบในพื้นที่อื่นมาก่อน ส่วนอีก 167 สปีชีส์พบเฉพาะถิ่น กลุ่มออสตราคอดประกอบด้วยตระกูล Bairdioidea Kloedenellidae Kirkbyidae Hollinellidae Paraparchitidea Cytherideidae Cavellinidae Pachydomellidae Aparchitidea Coelonellidae และ Polycopidae ซึ่งเป็นกลุ่มที่พบในเขตทะเลตื้น อาศัยอยู่ระหว่าง marginal marine ถึง exterior platform การแปลความหมายสภาพแวดล้อมบรรพกาลโดยอาศัยลักษณะนิเวศวิทยาของกลุ่ม ออสตราคอดบ่งชี้ว่า ในพื้นที่เลย หน้าตัดหินที่ศึกษาที่ถ้ำน้ำมโหฬารและเหมืองศักดิ์ชัยสะสมตัวในเขตทะเลเปิดใต้ระดับน้ำขึ้นน้ำลง ต่ำกว่าระดับที่ได้รับอิทธิพลจากคลื่นระหว่าง interior ถึง exterior platform ในช่วงความเค็มปกติ (เพอร์เมียนตอนต้น) ในพื้นที่เพชรบูรณ์ หน้าตัดหินเขาคณาสะสมตัวในสภาพแวดล้อมแบบน้ำตื้นถึงตื้นมาก มีระดับความเค็มแปรผันและมีการสะสมของตะกอนจากฝั่งมาก ในขณะที่หน้าตัดหินหนองไผ่สะสมตัวใต้ระดับน้ำขึ้นน้ำลง ภายใต้อิทธิพลของคลื่นบน interior platform (เพอร์เมียนตอนต้น) หน้าตัดหินภูพระธาตุและบ้านเนินสวรรค์ 1 สะสมตัวในเขตทะเลเปิด น้ำตื้นถึงน้ำตื้นมาก มีระดับความเค็มแปรผัน หน้าตัดหินบ้านเนินสวรรค์2 สะสมตัวในเขตทะเลเปิด ใต้ระดับน้ำขึ้นน้ำลง ภายใต้อิทธิพลของคลื่น (เพอร์เมียนตอนกลาง) ในพื้นที่นครสวรรค์-ลพบุรี หน้าตัดหินพุลำไยสะสมตัวในเขตทะเลเปิดใกล้ชายฝั่งต่ำกว่าระดับน้ำขึ้นน้ำลง และมีปริมาณตะกอนจากฝั่งมาก (ปลายเพอร์เมียนตอนต้น) หน้าตัดหินตาคลีสะสมตัวในเขตทะเลเปิด ภายใต้ระดับน้ำขึ้นน้ำลง อยู่ห่างจากชายฝั่งและมีการสะสมตัวของตะกอนที่มีสารอินทรีย์มาก (เพอร์เมียนตอนกลาง) หน้าตัดหินเขาสมโภชน์สะสมตัวในเขตทะเลเปิดใต้ระดับน้ำขึ้นน้ำลง มีการสะสมตัวของสารอินทรีย์มาก ในช่วงความเค็มปกติ (ปลายเพอร์เมียนตอนกลาง) มีปริมาณออกซิเจนในน้ำทะเลประมาณ 5 มิลลิลิตร/ลิตร ในทุกหน้าตัดหิน

ซึ่งพิจารณาจากร้อยละของจำนวนออสตราคอดที่ดักกรองกินอาหาร (Filter feeder) กับออสตราคอดที่กินเศษตะกอนบนพื้น (Deposit feeder)

ออสตราคอด 29 สปีชีส์ ที่ถูกพบในพื้นที่อื่นภายในเขตทะเลพาเลโอเทธิส (Paleotethys) ทุกชนิดรวมทั้งตัวอ่อนอาศัยอยู่บนหรือในพื้นตะกอน ดัชนีขอบเขต (Provincial index) บ่งชี้ว่ามีความใกล้ชิดมากกับพื้นที่จีนตอนใต้ และกับพื้นที่ ตูนีเซีย กรีซ โอมาน อิตาลี ฮังการี อิสราเอล ตามลำดับมากไปหาน้อย แต่ความใกล้ชิดน้อยกับสปีชีส์ในอเมริกาเหนือ ออสตราคอดอาจถูกกระแสน้ำในมหาสมุทรพัดพาไปยังพื้นที่ไกล ๆ จากฝั่งตะวันออกไปตะวันตกของทะเลพาเลโอเทธิส ทั้งนี้ ออสตราคอดสปีชีส์ที่พบทั่วไประหว่างหน้าตัดหินในพื้นที่ศึกษาบ่งชี้ว่าหินปูนเพอร์เมียนบนแผ่นทวีปอินโดไชน่า สะสมตัวในเขตน้ำตื้นไม่ไกลจากกันมาก ซึ่งทำให้ออสตราคอดสามารถเคลื่อนที่หรือกระจายตัวไปได้

สาขาวิชาชีววิทยา

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ลายมือชื่ออาจารย์ที่ปรึกษา__________________

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ลายมือชื่ออาจารย์ที่ปรึกษาร่วม________________

ANISONG CHITNARIN : TAXONOMY OF PERMIAN OSTRACODS FROM CENTRAL, NORTHEASTERN, AND WESTERN THAILAND: IMPLICATION FOR PALEOENVIRONMENT AND PALEOBIOGEOGRAPHY. THESIS ADVISOR : ASST. PROF. NATHAWUT THANEE, Ph.D. 322 PP.

OSTRACODS/TAXONOMY/PALEOENVIRONMENT/PALEOBIOGEOGRAPHY/ THAILAND

Fifteen sections and two localities of Early to late Middle Permian limestones in Loei, Phetchabun, Nakhon Sawan-Lopburi, and Kanchanaburi areas were investigated. Limestones were collected and processed by the hot acetolysis which yielded many ostracods. They are belonged to 196 species and 41 genera of which 29 species are known from other places, 167 species are endemic. The ostracod assemblages including Bairdioidea, Kloedenellidae, Kirkbyidae, Hollinellidae, Paraparchitidea, Cytherideidae, Cavellinidae, Pachydomellidae, Aparchitidea, Coelonellidae, and Polycopidae are typical shallow marine species from marginal marine to exterior platform environments. Interpretation of paleoenvironment based on paleoecological characteristic of the ostracod families and/or superfamilies suggests that: in the Loei area, Tham Nam Maholan and Sak Chai Quarry sections represent open marine environment, subtidal, below wave influences, from interior to exterior platforms with normal salinity (Early Permian); in the Phetchabun area, Khao Kana section represents shallow to very shallow water, with high terrigenous sediments and wide range of salinity whereas Nong Phai section represents deposition in subtidal zone, under wave influence, within interior platform (Early Permian), Phu Pra That and Ban Naen Sawan I sections

represent open marine environment, shallow to very shallow water with high terrigenous deposits and wide range of salinity to normal salinity, Ban Naen Sawan II section represents open marine environment, subtidal, under wave influence (Middle Permian); in the Nakhon Sawan-Lopburi area, Phu Lam Yai section represents open marine environment, subtidal, nearshore with high terrigenous deposits (late Early Permian), Ta Kli section represents open marine environment, subtidal, offshore zone with high contents of organic matter, with normal salinity (Middle Permian), Khao Som Phot section represents open marine environment, subtidal, with high terrigenous deposits and normal salinity (late Middle Permian). Oxygen concentration is approximately 5mL/L at all sections according to percentage of filter-feeding and deposit-feeding ostracods.

Twenty-nine ostracod species known from other Permian sites within Paleotethys region are benthic inhabitants and their larvae have the same way of life. Provincialism index suggests close relationships mainly with South China, and less level with Tunisia, Greece, Oman, Italy. The relationships with North American species are low. The ostracods could be carried to the remote sites by surface paleocurrents from east to west in Paleotethys realms during the Permian. Presence of common species between the studied areas suggest that limestones of the Indochina Block were deposited in shallow marine environments not far from each other where benthic ostracod fauna was able to travel or migrate.

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ANISONG CHITNARIN : TAXONOMIE DES OSTRACODES PERMIENS DE THAÏLANDE CENTRALE, NORD-ORIENTALE ET OCCIDENTALE : IMPLICATIONS SUR LE PALEOENVIRONNEMENT ET LA PALEOBIOGEOGRAPHIE. DIRECTEUR DE THESE: ASST PROF. NATHAWUT THANEE, PHD, 322 PP.

OSTRACODES/TAXONOMIE/PALEOENVIRONNEMENT/PALEOBIOLOGEOGRAPHIE/ THAÏLANDE

Quinze coupes et deux localités de calcaires du Permien inférieur à moyen terminal appartenant au Groupe de Loei, Groupe de Saraburi et au Calcaire de Sai York (dans les régions de Loei, Petchabun, Nakhon Sawan-Lopburi et Kanchanaburi) ont été étudiées. Les calcaires qui ont été échantillonnés et traités par acétolyse à chaud, renferment de nombreux ostracodes. Ils appartiennent à 196 espèces et 41 genres. 29 espèces sont connues avec d'autres régions, 167 sont endémiques. Les assemblages d'ostracodes, comprenant des Bairdioidea, Kloedenellidae, Kirkbyidae, Hollinellidae, Paraparchitidea, Cytherideidae, Cavellinidae, Pachydomellidae, Aparchitidea, Coelonellidae et Polycopidae, sont typiquement des espèces marines peu profondes dans des environnements marins marginaux à de plate-forme externe. L'interprétation des paléoenvironnements basée sur les caractéristiques paléoécologiques des familles et/ou superfamilles suggère que:

- Dans la région de Loei, pour les coupes de Tham Nam Maholan et de la carrière de Sak Chai, les environnements de dépôts étaient marin ouvert, en zone subtidale, en dessous de l'action des vagues, de plate-forme interne à externe, avec des salinités normales (Permien inférieur)

- Dans la région de Petchabun, la coupe de Khao Kana présente des environnements de dépôts en zone subtidale, sous l'influence de l'action des vagues, sur la plate-forme interne, en environnement euryhalin, probablement entre les zones intertidale et

subtidale. La coupe Ban Naen Sawan II correspond à des milieux de dépôts marin ouvert, en zone subtidale, sur la plate-forme interne, sous l'influence de l'action des vagues (Permien moyen).

- Dans la région de Nakhon Sawan-Lopburi, la coupe de Phu Lam Yai est caractérisée par des environnements de dépôts très peu profonds en zone intertidale (Permien moyen); la coupe de Khao Som Phot correspond vraisemblablement à des environnements de dépôts marin ouvert à salinité normale sur la plate-forme externe (Permien moyen supérieur)

- Les concentrations en oxygène dans l'eau, évaluées à partir des pourcentages d'ostracodes filtreurs vs détritivores, seraient approximativement de l'ordre de 5ml/l pour toutes les coupes.

Vingt neuf espèces d'ostracodes sont reconnues dans d'autres régions de la Paléo-Téthys. Ces espèces sont benthiques et leurs larves ont le même mode de vie. L'indice de provincialisme suggère des relations étroites avec la Tunisie, la Chine du Sud, la Grèce, l'Oman, l'Italie, la Hongrie et Israël, en ordre décroissant. Les relations avec l'Amérique du Nord sont faibles. Les ostracodes peuvent avoir été transportés vers des régions éloignées par des courants de surfaces de l'est vers l'Ouest de la paléo-Téthys au cours du Permien. La présence d'espèces communes entre les régions de Loei, Phetchabun, et Nakhon Sawan-Lopburi suggèrent que les calcaires des groupes de Loei et de Saraburi se sont déposés dans des environnements marins peu profonds, peu éloignés les uns des autres, où les faunes d'ostracodes benthiques pouvaient se déplacer ou migrer.

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Anisong Chitnarin

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CHAPTER I

INTRODUCTION

Ostracods are known to be one of the most diverse group of crustacean and the excellent group of microfossils for paleoecology. Due to their wide ecological tolerance, ostracods are able to live in all aquatic environements, i.e. terrestrial to marine. By this way, they could be recovered in fossil register in all the sediments. The fauna has been recorded from Ordovician to Recent (time) and from all continents (space). Numbers of research have revealed that fossil ostracods play an important role for paleoecological reconstructions. They are also a potential tool to understand paleogeography of the relevant area.

1.1 Significant of the study

Unlike other Permian invertebrate fossils, the ostracods are quite unknown in Thailand. In fact, the ostracod have been recognized in rock thin sections and mentioned in some research papers (Chonglakmani and Fontaine, 1990; Dawson and Racey, 1993). The absence of this knowledge has called for dissertation which could provide taxonomy of the ostracods. Although, it is accepted that the ostracods are valuable for paleoecology and paleogeography (De Deckker and Forester, 1988; Melnyk and Maddocks, 1988a; 1988b; Whatley, 1988), such investigations are rare in Thailand. Therefore, this research is not only the detailed one to emphasize on the taxonomy of Permian ostracods and their applications to paleoenvironmental analysis and paleobiogeographic interpretation, it also provides additional information of the ostracods in Thailand.

1.2 Research objectives

This research is aimed to 1) explore and establish taxonomy of the fossil ostracods recovered from the Permian strata of northeastern, western and central Thailand, 2) to analyze the paleoecological condition by considering the ostracod assemblages, and finally, 3) reconstruct the paleobiogeography of the study ostracods.

1.3 Previous Permian ostracod study in Thailand

Fontaine (1986) mentioned shortly about discovery of Hahn and Siebenhuner in 1982 of the Permian ostracods genera *Amphissites* and *Polytylites* from Nan province, and genus *Healdia* from Mae Hong Son province, both from northern Thailand. Generally, sections of the ostracod valves and carapaces have been recognized in microphotographs as referred in several geological reports conducted by Department of Mineral Resources. However, less is known about ostracods and taxonomic affinity. Up to now, Chitnarin *et al*. (2008) is the only work on the Middle Permian ostracods from Thailand which the study section, a part of the Tak Fa Formation in Phetchabun province was investigated. Fifteen species were reported in which four new species were described (*Sargentina*? *phetchabunensis*, *Geffenina bungsamphanensis*, *Reviya subsompongensis*, *Bairdia takfaensis*). The ostracod assemblages characterized a shallow marine, near shore environment at the time of deposition. The only single species shows paleobiogeographical links between central Thailand and south China, others are endemic.

1.4 Contents of the thesis

This thesis is presented as follows;

First of all, 1-informations on general geology and stratigraphy of the Permian strata relevant to this research are introduced in the first part of Chapter II. Consequently, details of the study sections are given in the last section of the chapter.

Second, 2-generality of the ostracods (classification, fossil preparation), 3-systematic paleontology of the study ostracods (Chapter III).

Next, 4-ostracod assemblages and their application on the paleoecology (Chapter IV).

Then, 5-paleobiogeography of the study ostracods is established and presented (Chapter V).

Finally, 6-results from all above are discussed and concluded (Chapter VI).

CHAPTER II

GENERAL GEOLOGY AND GEOLOGY OF THE STUDY SECTIONS

This chapter is aimed to introduce general geology in regional and local scales of the Permian rocks relevant to this thesis. Therefore, it can be divided into three parts. The first part presents tectonic history of the Permian in Thailand. The second part summarizes Permian lithostratigraphy of the study areas. And the last part provides information of the study sections (locality, lithology, and age determination).

2.1 Tectonic history of the Permian in Thailand

Topics on tectonic history of Southeast Asia including Thailand have been interested by many researchers since the last few decades, and much of the debate has been emphasized on time and location where the Paleotethys was closed. (Bunopas, 1981; Metcalfe, 1990; 2002; Ueno, 1999; 2002; Ueno and Hisada, 1999). The Paleotethys, an ancient Paleozoic ocean, was opened in Devonian when some continental terranes were separated from north Gondwanaland (Bunopas, 1981; Metcalfe, 1990; 2002). These foregoing terranes including South China, North China, Tarim and Indochina are well known as the Cathaysian terranes. Subsequently, the Cimmerian terranes including Turkey, Iran, northern Afghanistan, northern Tibet and Sibumasu block were also rifted from Gondwanaland in the late Early Permian.

Afterward, the Cimmerian terranes moved to the lower latitude and merged with the Cathaysian terranes within the tropical Tethyan Province (Figure 2.1).

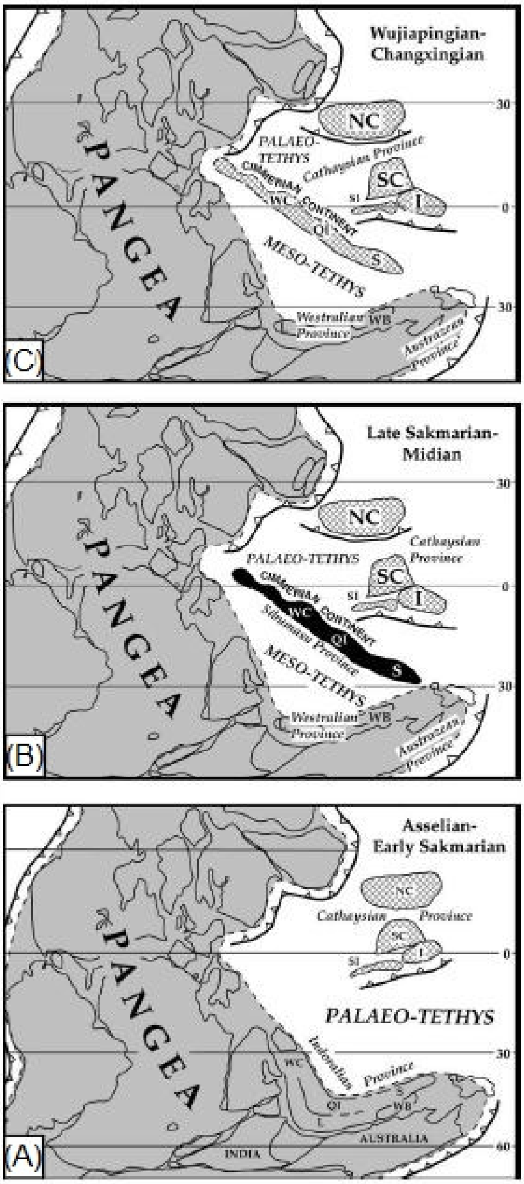

Figure 2.1 Paleogeographic reconstructions for (A) Early Permian (Asselian-Early Sakmarian); (B) Lower to Middle Permian (Late Sakmarian-Capitanian); (C) Late Permian (Wujiapingian-Changsingian) from Metcalfe (2002). The maps illustrate a tectonic vicariant model interpreting the change in marine provinciality of the Cimmerian continent during the Permian.

Thailand and the neighboring countries have been known to be an amalgamation of several terranes where the Paleotethys remnant can be found in present day. A simple model of Bunopas (1992) was originally accepted that the Indochina terrane to the east and the Shan-Thai terrane to the west are divided by the Nan Suture. However, the later intensive researchers prefer more complicated geotectonic scenarios (Metcalfe, 1990; 2002; Ueno, 1999; 2002; Ueno and Hisada, 1999); that is, the formation of this region had undergone several tectonic evolutions according to time-related sutures/fault zones.

Ueno (2002) reviewed and traced geotectonic linkage between West Yunnan and mainland Thailand. As a result, four geotectonic units were recognized for the mainland Thailand; namely the Indochina Block, Sukhothai Zone, Intanon Zone, and Sibumasu Block, from east to west (Figure 2.2) which are bounded by three major tectonic lines; the Nan-Uttaradit Suture (extended to Southeast Thailand as the Sa Kaeo-Chanthaburi Suture), Chiang Rai Tectonic line, and Mae Yuam Fault, respectively. The Indochina Block comprised of eastern Thailand, Laos, Cambodia and parts of Vietnam had been situated in the paleo-tropical region after its separation from Gondwana. The Nan-Uttaradit Suture lying between the Indochina Block and the Intanon Zone is regarded as a remnant of a back-arc basin that was active in probably the Permian and closed in the Triassic (Ueno, 1999; 2002; Ueno and Hisada, 1999). The Sukhothai Zone dominated by Paleozoic-Mesozoic sedimentary and volcanic rocks and Triassic I-type granite is regarded as a Permian-Triassic island arc developed along the margin of the Indochina Block. The Chiang Rai Tectonic line is evidenced by mafic/ultramafic rocks scatteringly found from Chiang Rai to Chiang Mai which separates the eastern Cathaysian domain and western Gondwana domain, can be regarded as the remnant of the Paleotethys in Thailand. This suture would extend to a cryptic tectonic line running east of Chonburi and Rayong in southeast Thailand. The Sibumasu Block located in westernmost part occupies westernmost Thailand, eastern Burma, and peninsular of both countries to western peninsular of Malaysia and Sumatra. The Early Permian glaciogene diamictite is significant for its stratigraphy. The Sibumasu Block is bounded to the east by the Mae Yuam Fault as shown in Figure 2.2.

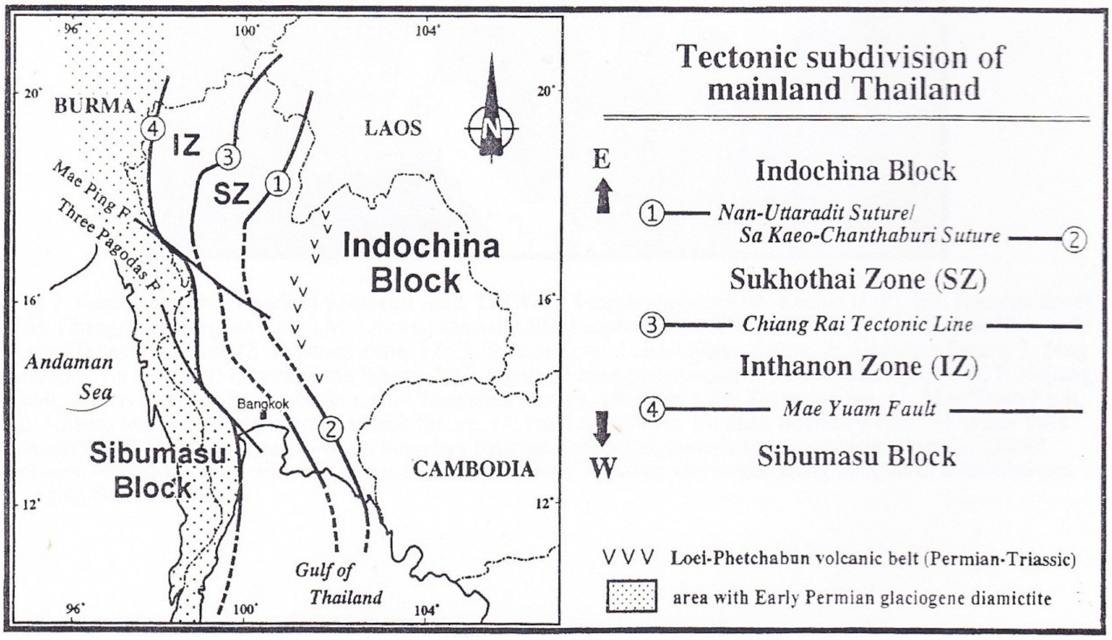

Figure 2.2 Geotectonic subdivisions of mainland Thailand (Ueno, 2002).

2.2 Permian lithostratigraphy of the study areas

Permian rocks, predominantly carbonates with minor clastics, are extensively exposed throughout Thailand. The rocks were originally called Ratburi Limestone (Brown *et al*., 1951); then, Ratburi Group was proposed (Javanaphet, 1969) for Permian rocks which are limestones with association of clastic and volcanic sediments. Later on, lithology and sedimentology of the Permian rocks were obtained from various geological mapping and researches by many authors throughout the country (Bunopas, 1971; Charoenprawat and Wongwanich, 1976; Chonglakmani and Sattayalak, 1979; Hinthong, 1981; Nakornsri, 1977; 1981; Piyasin, 1972). Thus, a number of Formations and Groups have been proposed formally and informally. The overall thickness of the Permian rocks varies from several hundred to about four thousand meters (Bunopas, 1981; 1983). On the stratigraphy, the Permian rocks usually overlie conformably on Carboniferous rocks and are overlain unconformably by either Triassic rocks or Permo-Tiassic volcanic and volcanic-clastic rocks.

Assavapatchara *et al*. (2006) complied and reviewed lithostratigraphy of the Permian rocks in Thailand; therefore, the Permian rocks distributed in northern and western highlands, peninsula, eastern gulf, and central plain and Phetchabun range are subdivided into 11 Groups. According to them, limestones of the Sai Yok Group, the Saraburi Group, and the Loei Group are involved in this thesis (Figure 2.3). It should be noted that the Loei Group was informally used by Assavapatchara *et al*. (2006). Besides, terms "limestones of the Sibumasu Block" and "limestones of the Indochina Block" are introduced in this study for the geotectonic view point (see Figure 2.2); that is, the former for the Sai Yok Group, the latter for the Saraburi and Loei Groups. Brief information on these rocks are summarized below.

2.2.1 Limestones of the Sibumasu Block

As mentioned prior, the Sibumasu Block was separated from north Gondwana in late Early Permian, and drifted northward to tropical region. The Permian rocks of the Sibumasu Block are different in their lithology and history. Bunopas (1981) investigated the Permian rocks exposed in Kanchanaburi area and established the Sai Yok Group which consists of the Khao Muang Khrut Formation (sandstones, shales and

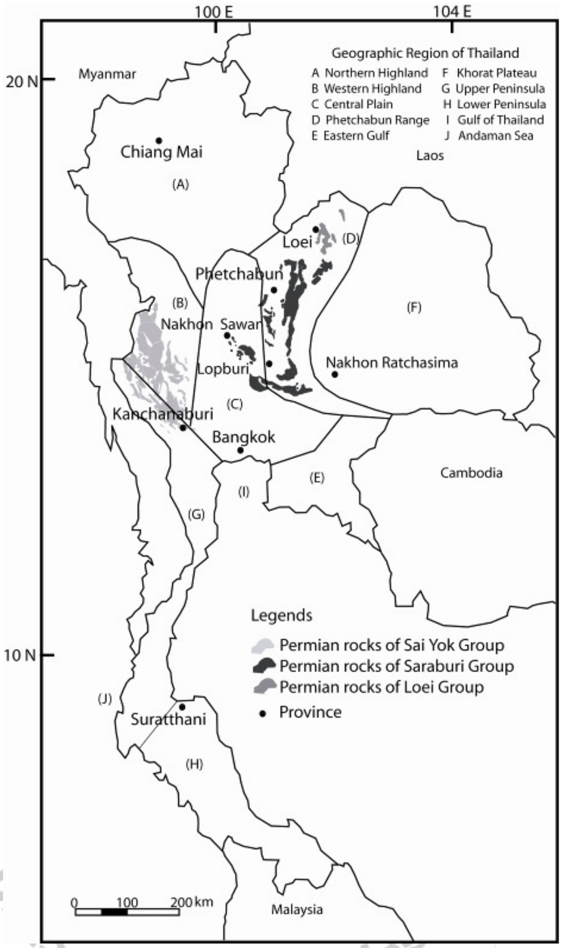

Figure 2.3 Distributions of Permian rocks of the Sai Yok, the Saraburi, and the Loei Groups (after Assawapatchara *et al*., 2006).

calcareous sandstones), the Sai Yok Limestone (calcarenites, sandstones, limestones and dolomitic limestones), and the Tha Madua Formation (sandstones, shales) in ascending order (Figure 2.4A). The Group is ranged from Early to Middle Permian age based on fusulinaceans and brachiopods (Bunopas, 1992).

The Sai Yok Limestone can be distinguished by lithology; the lower part is composed of calcarenites and sandstones containing *Parafusulina* sp. and *Eopolydiexodina* sp.; the middle part consists of massive limestones and dolomitized

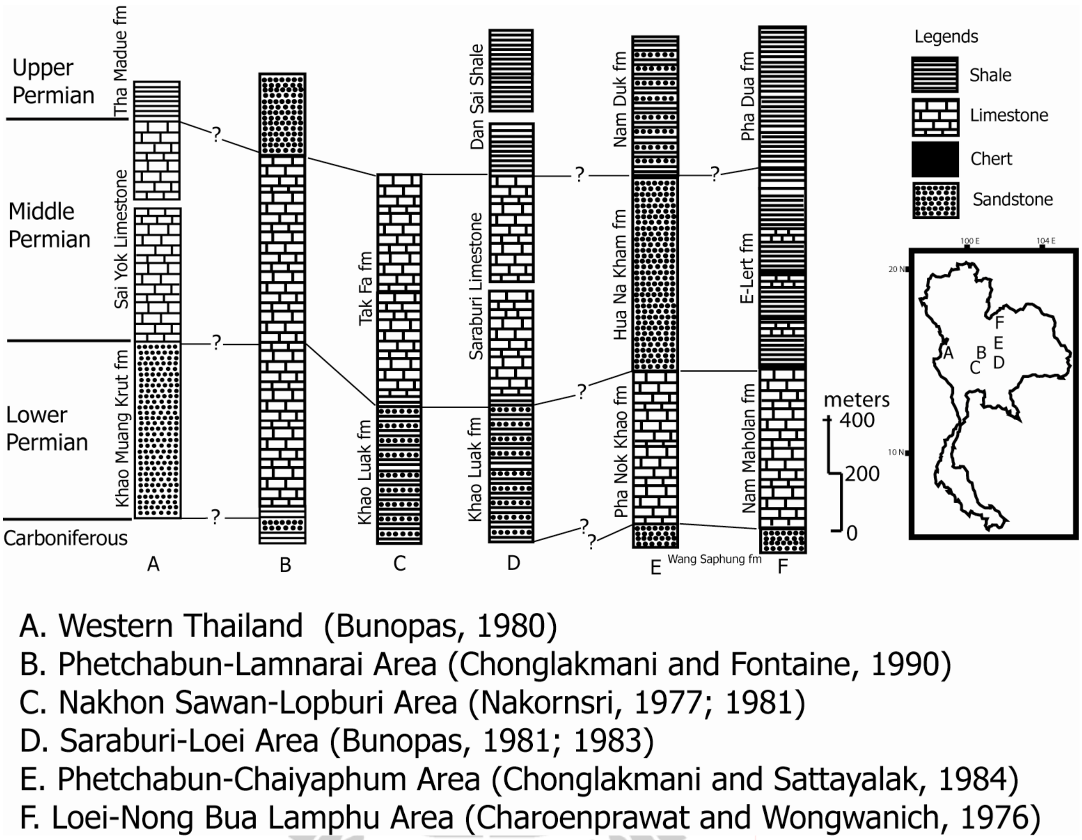

Figure 2.4 Lithostratigraphic columns and correlations of the Permian strata relevant to this research (after Assawapatchara *et al*., 2006).

limestones; the upper part is of recrystaline limestones and sandstones. Therefore the age of the formation is probably Middle Permian (Wordian age).

2.2.2 Limestones of the Indochina Block

The Permian rocks exposed in the central plain and the Phetchabun range are different in lithology and history from those of the Sibumasu Block. The rocks were investigated and established to the Saraburi Group (Bunopas, 1981; 1992). During that time, the Permian rocks in this region were also investigated and studied by many researchers (Charoenprawat and Wongwanich, 1976; Chonglakmani and Sattayalak, 1979; Hinthong, 1981; 1985; Nakornsri, 1977; 1981; Wielchowsky and Young, 1985). Hence, geological maps and many rock Formations were established almost at the same period.

- The Permian rocks in the Nakhon Sawan-Lopburi area

Nakornsri (1977; 1981) divided the Permian rocks in the central plain into the Khao Luak and the Tak Fa Formations in ascending order (Figure 2.4C). The Khao Luak Formation consists of shales, sandstones and thin-bedded limestones in the upper part and the tuffaceous sandstones in the lower part. In contrast, the Tak Fa Formation consists mainly of fossiliferous limestones with fusulinaceans, corals, brachiopods and bryozoans which indicate the Early Permian (Artinskian to Kungurian age). The age of Early to late Middle Permian of the Tak Fa Formation has been reported by several authors; for instance, Wielchowsky and Young (1985), Udchachon *et al*. (2007), and Sone *et al*. (2009).

- The Permian rocks in the Phetchabun area

The rocks in the Phetchabun area are subdivided into the Pha Nok Khao Formation (limestones with nodular cherts and shales), the Hua Na Kham Formation (shales, sandstones, limestones), and the Nam Duk Formation (black shales, sandstones and limestones) according to Chonglakmani and Sattayalak (1979) (Figure 2.4E). The age of the formations ranges from Early Permian to late Middle Permian with reference to fusulinaceans (Altermann, 1989). Later on, Chonglakmani and Fontaine (1990) investigated carbonate strata in the Phetchabun-Lam Narai area; thus, Carboniferous and Permian corals, fusulinaceans and other fossils were discovered which suggest the continuous deposit within shallow marine platform during Carboniferous to Middle Permian (Figure 2.4B).

- The Permian rocks in the Loei area

The Permian rocks exposed in the Loei area and vicinity are subdivided into the Nam Maholan Formation, the E-Lert Formation and the Pha Dua Formation (Charoenprawat and Wongwanich, 1976) in ascending order (Figure 2.4F). The rocks represent shallow marine carbonate deposits (limestones of the Nam Maholan), shallow marine clastic deposits (argillaceous limestones, shales and sandstones of the E-Lert), and shallower clastic deposits (sandstones, siltstones and shales of the Pha Dua). The age of these rocks ranges from Early Permian to late Middle Permian according to fusulinaceans, ammonoids, and plants (e.g., Asama *et al*., 1968; Altermann, 1989; Charoentitirat and Ueno, 1999).

2.3 Geology of the study sections

The study area is subdivided into four areas, namely the Loei, the Phetchabun, the Nakhon Sawan-Lopburi, and the Kanchanaburi areas, in order to recognize their geographic locations. It should be reminded that the Kanchanaburi area is belonged to the Sibumasu Block, others are belonged to the Indochina Block. According to dissimilarity of lithology and sedimentary facies of the Permian rocks exposed in different areas, 15 sections were studied in this research in order to observe diversity of ostracods in space and time (Figure 2.5 and Table 2.1). Therefore, 12 sections yielded fossil ostracods. In addition, limestone samples collected from two isolated localities also yielded some ostracods and are included in this study.

The Loei area (Figure 2.6)

2.3.1 Khao Tham Yai locality (08LO01); (Figure 2.6)

Khao Tham Yai is a name of a huge mountain located north of Nam Nao District in Phetchabun Province, and is belonged to the Pha Nok Khao formation

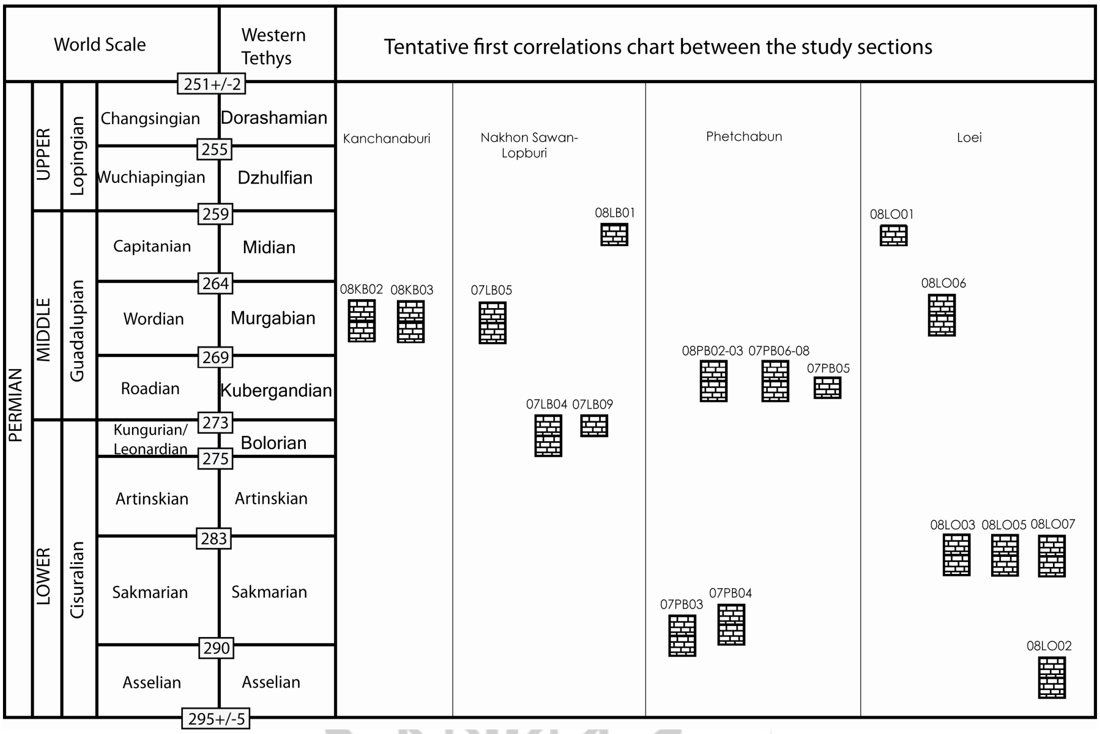

Figure 2.5 Tentative first correlations chart between the study sections from the Kanchanaburi, Nakhon Sawan-Lopburi, Phetchabun, and Loei areas.

(Chonglakmani and Sattayalak, 1979). The location was well investigated by Fontaine *et al*. (2002); the late Middle Permian age was designated by fusulinaceans such as *Sumatrina* sp. In this study, four limestone samples were collected from stream outcrop in front of the Khao Tham Yai cave (at 101° 23’ 37”E, 16° 56’ 22”N). These samples also contain *Sumatrina* sp. which reassures the age of Middle Permian, Capitanian stage (Figure 2.7A and B). Some ostracods were recovered from this locality and are included in this thesis.

2.3.2 Tham Nam Maholan section (08LO02); (Figures 2.6 and 2.8)

Tham Nam Maholan, the name of a mountain and a temple, is located about 25 km southeast of Wang Saphung District in Loei Province. The location is considered to be type section of the Nam Maholan Formation (Charoenprawat and

Table 2.1 Information of the study sections with results of fossil ostracods

AA	Section number	Section name	Provincial locality (District, Province)	Geographic position	T (m)	N	R
A	08LO01	Khao Tham Yai	Nam Nao, Phetchabun	101°23'37"E 16°56'22"N	p	4	F
	08LO02	Tham Nam Maholan	Wang Saphung, Loei	101°52'48"E 17°06'23"N	40	12	G
	08LO03	Phu Pha Khun	Phu Kra Dung, Loei	101°57'03"E 16°51'40"N	60	12	P
	08LO05	Sila Sriburi Quarry	Chumpae,Khon Khean	101°57'26"E 16°43'37"N	50	13	F
	08LO06	Ban Khao Wong	Khon San, Chaiyaphum	101°47'23"E 16°38'36"N	30	8	P
	08LO07	Sak Chai Quarry	Khon San, Chaiyaphum	101°52'38"E 16°35'07"N	90	13	G
B	07PB03	Khao Kana	Chon Dan, Phetchabun	100°54'20"E 16°04'12"N	15	7	G
	07PB04	Nong Phai	Nong Phai, Phetchabun	100°58'59"E 16°01'06"N	30	7	G
	07PB05	Ban Naen SawanI	Bung Sam Phan, Phetchabun	100°53'36"E 15°54'11"N	30	7	G
	07PB06-07PB08	Ban Naen SawanII	Bung Sam Phan, Phetchabun	100°55'46"E 15°55'08"N	90	21	G
	08PB02-08PB03	Phu Phra That	Chon Dan, Phetchabun	100°52'21"E 15°58'22"N	70	19	F
C	07LB04	Phu Lam Yai	Tak Fa, Nakhon Sawan	100°36'15"E 15°20'21"N	30	18	G
	07LB05	Ta Kli	Ta Kli, Nakhon Sawan	100°22'46"E 15°19'05"N	50	20	G
	07LB09	Khao Phu Chongkho	Tak Fa, Nakhon Sawan	100°35'12"E 15°22'45"N	P	2	F
	08LB01	Khao Som Phot	Lam Sonthi, Lopburi	101°31'10"E 15°11'16"N	15	6	G
D	08KB02	Khao Pu Leab	Muang, Kanchanaburi	99°23'13"E 14°03'36"N	70	7	P
	08KB03	Ban Pu Pru	Muang, Kanchanaburi	99°16'10"E 14°05'27"N	40	9	F

Explanation: AA = area, A = the Loei area, B = the Phetchabun area, C = the Nakhon Sawan-Lopburi area, D = the Kanchanaburi area; T = thickness; N = number of rock samples; R = result on ostracods, F = fair, G = good, P = poor.

Wongwanich, 1976). This section was previously studied by some authors; for example, Igo (1972), Yanagida (1967; 1976). Assawapatchara (1999, unpublished) made a detailed study on lithology and lithostratigraphy of the whole mountain range, and subdivided the Formation into three members: the Tham Sue Mop, the Ban Nong

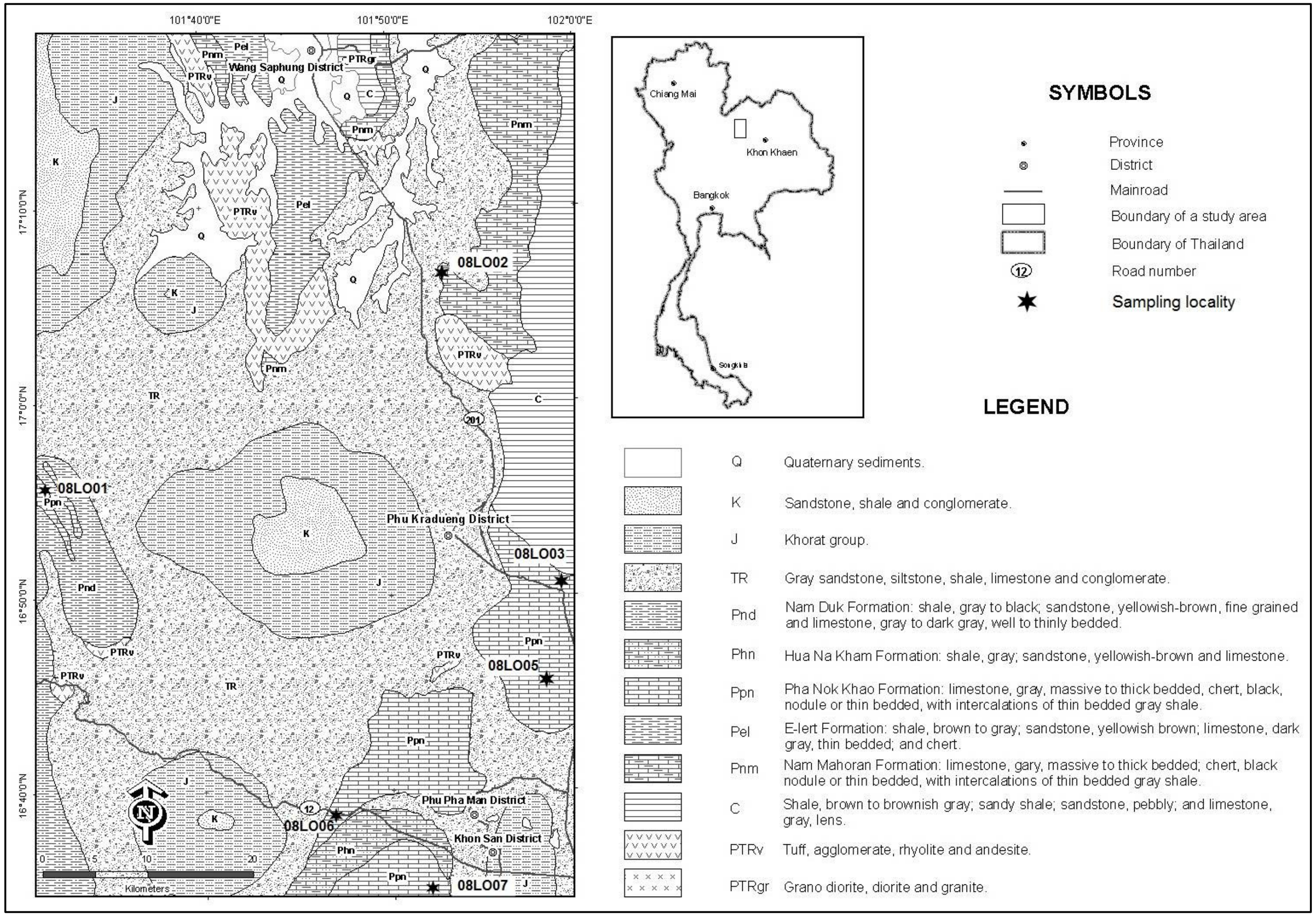

Figure 2.6 Geological map and sampling localities in the Loei area.

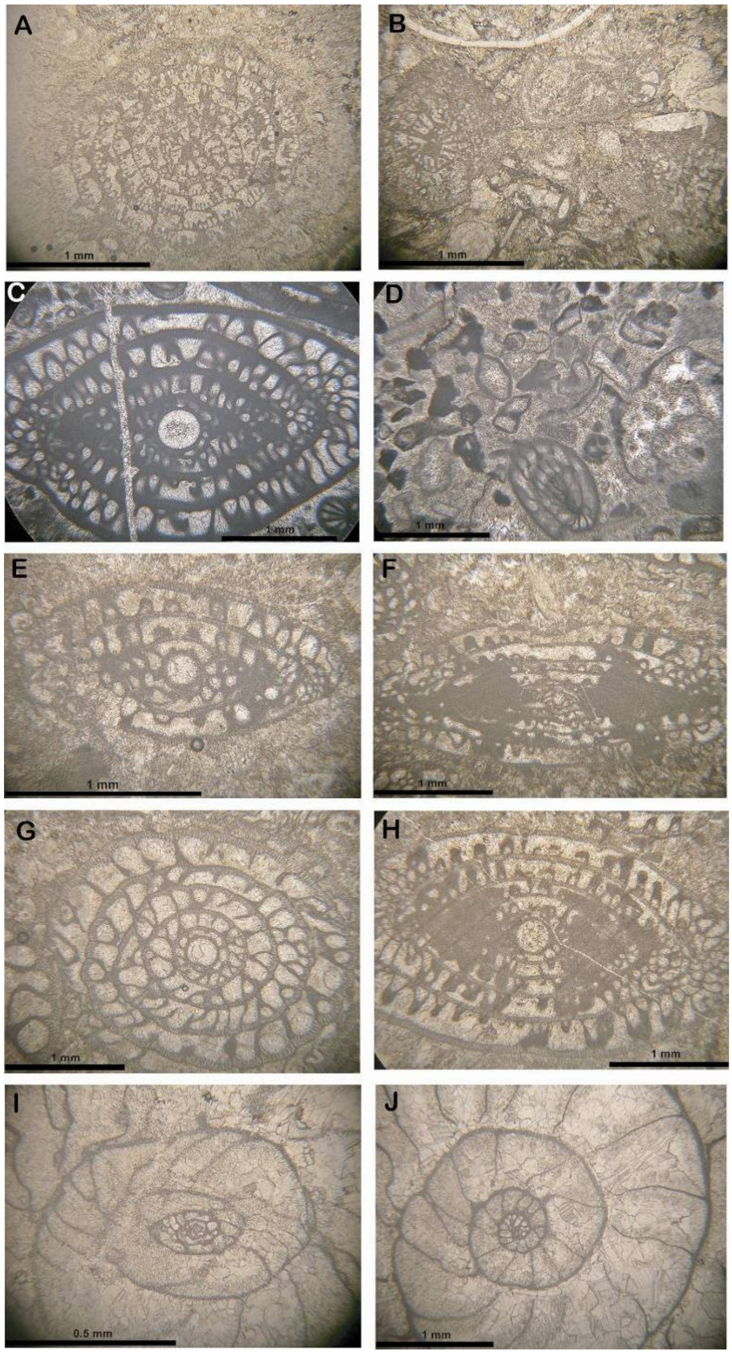

Figure 2.7 Microphotographs of fusulinaceans and limestone texture of selected rock samples in this study*

* **Explanation for Figure 2.7**: A and B: *Sumatrina* sp., sample No. 08LO01-4 from Khao Tham Yai locality, Phetchabun Province; C: fusulinid, sample No. 08LO02-5 from Tham Nam Maholan section, Loei Province; D: bioclasts and poorly washed texture of biomicritic limestone, sample No. 08LO02-5 from Tham Nam Maholan section, Loei Province; E and F: *Pseudofusulina* sp.1, sample No. 08LO07-11 from Sak Chai Quarry section, Loei Province; G and H: *Pseudofusulina* sp.2 sample No. 08LO07-11 from Sak Chai Quarry section, Loei Province; I and J: *Sphaeroschwagerina*? sp. sample No. 07PB04-2 from Nong Phai section, Phetchabun Province.

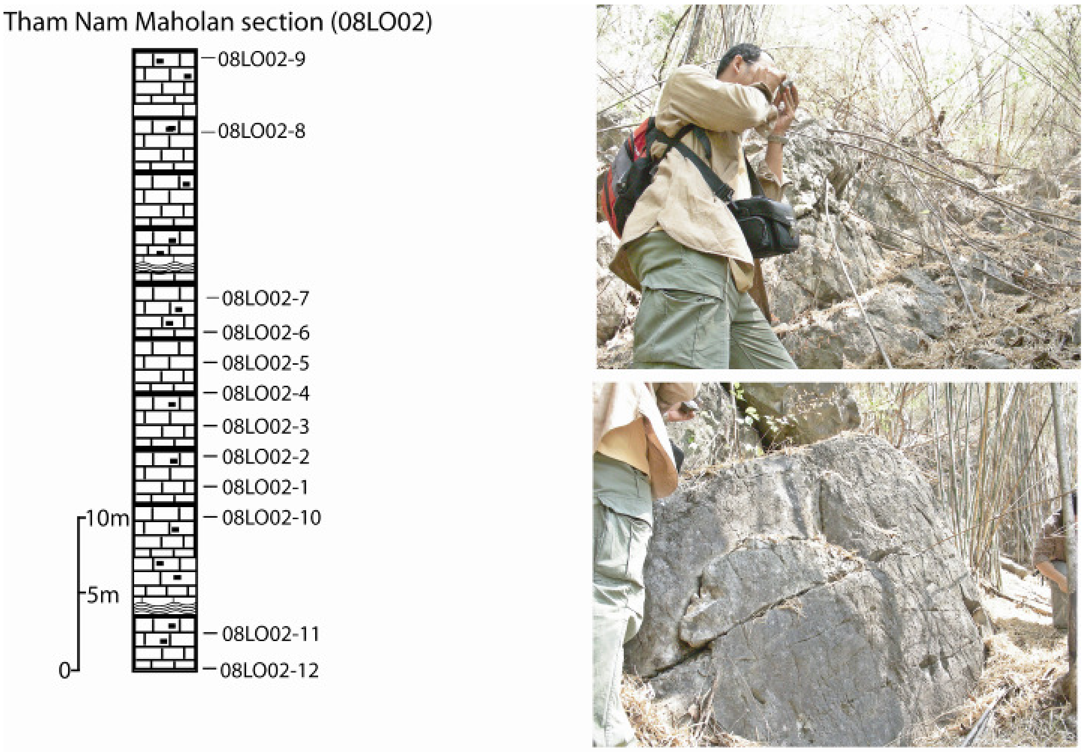

Figure 2.8 Lithologic log of Tham Nam Maholan section (08LO02) (left-see text for description), and photographs showing thick-bedded limestones at level 08LO02-1 (right)

Hin, and the Phu Pha Khao Members, in ascending order. The 08LO02 section is located at 101° 52’ 48”E, 17° 06’ 23”N, on the northwest side of the mountain and is belonged to a part of the Early Permian Phu Pha Khao Member of Assawapatchara (1999, unpublished). According to his work, the limestones are white to light gray, thick- to very thick-bedded biomicrite with poorly washed texture and biosparite, and is with moderately to poorly sorted, oosparudite with composited ooides and algal-lamination. Igo (1972) established fusulinacean zone of *Triticited ozawai-Paraschwagerina yanagidai* which indicates Asselian age for the Tham Nam Maholan locality. Assawapatchara (1999, unpublished) also reported fusulinaceans such as *Schwagerina* sp., *Pseudofusulina* sp., *Schubertella* sp., and *Parafusulina* sp. which indicate Early Permian age.

The study section (at 10 ° 52’ 48”E, 17 ° 06’ 23”N) is 40 m thick (Figure 2.8), and is consisted of thick- to very thick-bedded limestones. Limestones are white to light gray micritic limestone with sparse black allochems. Limestones can be classified to wackestones to packstones with bioclasts (fusulinaceans, small foraminifers, shell fragments) and intraclasts. Algal laminations are observed in the lower and the middle parts of the section. Brachiopods are observed, crinoid stems are found only in the upper part of the section. Totally, twelve limestone samples were collected from this section. Rock samples numbers 08LO02-1 and 08LO02-5 were cut and prepared for thin sections as presented in Figure 2.7 (C and D). Many ostracods were recovered.

2.3.3 Phu Pha Khun section (08LO03); (Figure 2.6)

Phu Pha Khun is the name of a mountain range located about 10 km southeast of Phu Kradung District in Loei Province. This small mountain range is faced by a huge Pha Nok Khao limestone mountain to the southwest across Highway No.201. This locality is located at 101° 57’ 03”E, 16 ° 51’ 40”N, is on an abandon part of the limestone quarry, and is belonged to the Pha Nok Khao Formation (Chonglakmani and Sattayalak, 1979). The measured section is of 60 m thick which is consisted of medium- to very thick-bedded limestone. Limestones are bluish gray, mudstones to wackestones with scared fossils such as small foraminifers and crinoid stems. Twelve limestone samples were collected and processed from this section; none of them yielded ostracod.

2.3.4 Sila Sriburi Quarry section (08LO05); (Figure 2.6)

The section is on an abandoned part of an active limestone quarry which is located in Na Nong Tum village, Chumphae District in Khon Kean Province. It is at 101° 57' 26"E, 16° 43' 37"N, about 30 km northwest of Chumphae city or about 15 km north of intersection between Highway No.12 and No.201. The section is belonged to the Pha Nok Khao Formation (Chonglakmani and Sattayalak, 1979) which comprises of thin- to medium-bedded, bluish gray to gray limestones with abundant brachiopods, fusulinids and crinoids stems. According to Wongprayoon and Seangsrichan (2009, unpublished) this locality is Early Permian in age. Totally, thirteen limestone samples were collected from the 50 m thick section; a single incomplete carapace is recovered.

2.3.5 Ban Khao Wong section (08LO06); (Figure 2.6)

The 08LO06 section is a road cut outcrop at 101° 47' 23"E, 16° 38' 36"N, at km78+800 on Highway No.12 which is located about 10 km west of Khon San District, Chaiyaphum Province. The 30 m-thick exposure is belonged to the Pha Nok Khao Formation (Chonglakmani and Sattayalak, 1979) which displays sequence of medium- to very thick-bedded limestones. Limestones of this location are of light gray to cream in colour, and of wackestones with bioclasts and intraclasts. Graded bedding is recognized in the lower part, and limestone breccias are found in the middle part of the section. There is an intercalation of thin-bedded silicified shales and thick-bedded limestones in the upper part of the section. Fragments of fossils such as ammonoids?, small foraminifers, and fusulinaceans (*Verbeekina* sp.) are recognized in field which suggest the age of Middle Permian, probably the Wordian age. Eight limestone samples were collected from this section; ostracods are absent.

2.3.6 Sak Chai Quarry section (08LO07); (Figures 2.6 and 2.9)

The section at 101° 52' 38"E, 16° 35' 07"N, is a part of an active limestone quarry in Tung Na Lao Village which is about 5 km west of Khon San District in Chaiyaphum Province. The section is belonged to the Pha Nok Khao Formation of Chonglakmani and Sattayalak (1979) showing sequence of medium- to very thick-bedded limestones intercalated with dark gray shales. Limestones are gray to dark gray in colour, are of wackestones to packstones with bioclasts, and are locally recrystalline. Nodular cherts are scattering found in the lower part of the section. Macro-fossils such as brachiopods, gastropods and crinoid stems are found only in the lower part of the section. In the middle part, there is about 20 m thick of massive limestones. Overlying the massive limestones, there is an intercalation of medium-bedded limestones in the upper part of the section where well preserved fusulinaceans are abundantly observed. The Early Permian age according to fusulinaceans is reported by Wongprayoon and Seangsrichan (2009, unpublished). Two rock samples collected from this section were prepared for thin sections by current authors (Figure 2.7 E and H); the presence of *Pseudofusulina* sp. suggests Early Permian age. Twelve limestone samples were collected from this locality, ten were disaggregated for ostracods; they yielded many ostracods.

The Phetchabun area (Figure 2.10)

2.3.7 Khao Kana section (07PB03); (Figures 2.10 and 2.11)

Khao Kana is a name of a NW-SE mountain range and a village south of Chon Dan District in Phetchabun Province. The section at 100° 54' 20"E, 16° 04' 12"N, is about km 22 to 23 on Highway No.2398 or about 14 km south of Chon Dan city. This area is belonged to the Pha Nok Khao Formation of Chonglakmani and Sattayalak

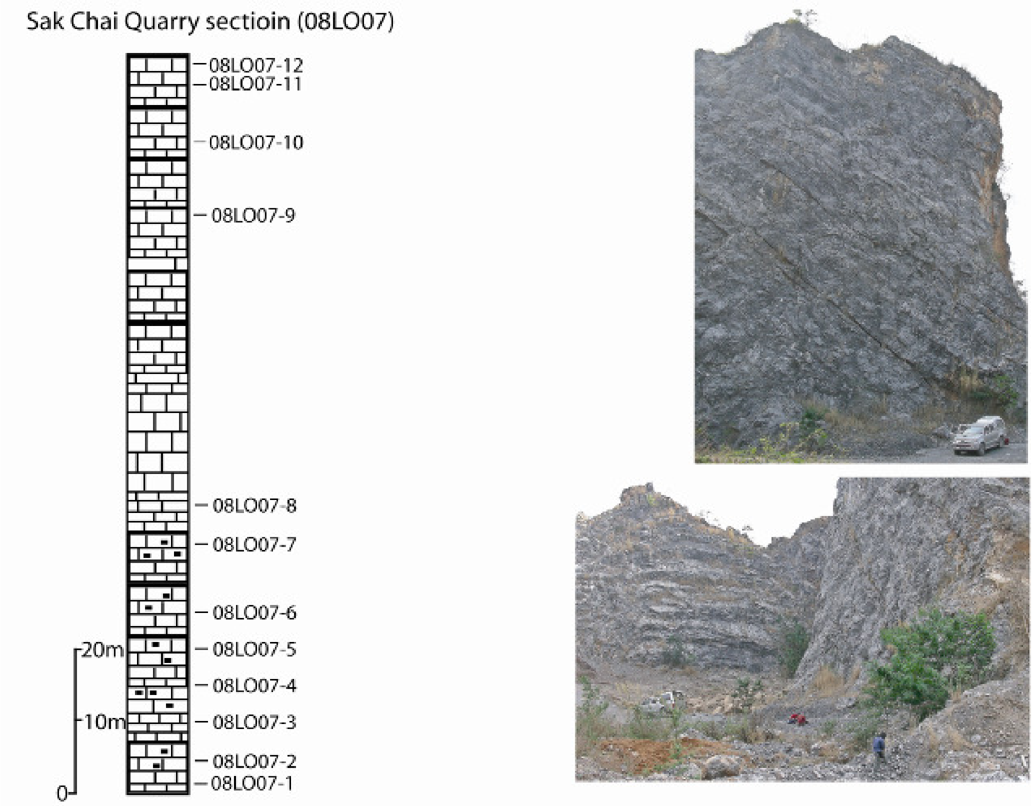

Figure 2.9 Lithologic log of the Sak Chai Quarry section (08LO07) (left-see text for description), and photographs showing an intercalation of medium-bedded limestones and shales (right)

(1979) where medium-bedded limestones are intercalated with thin-bedded siltstones showing attitude of N315/20° E. Limestones are dark gray in colour, are wackestones with bioclasts such as small foraminifers, brachiopods valves and ostracods. Brachiopods are found in some siltstone beds. Seven limestone samples, 07PB03-1 to 07PB03-7, were collected from this section which yielded many ostracods. The sample numbers 07PB03-1 and 07PB03-2 were prepared for thin sections; thus, small forams were recovered without fusulinacean. A sectioned ostracod carapace and limestone texture are shown on Plate 22, Figure 10.

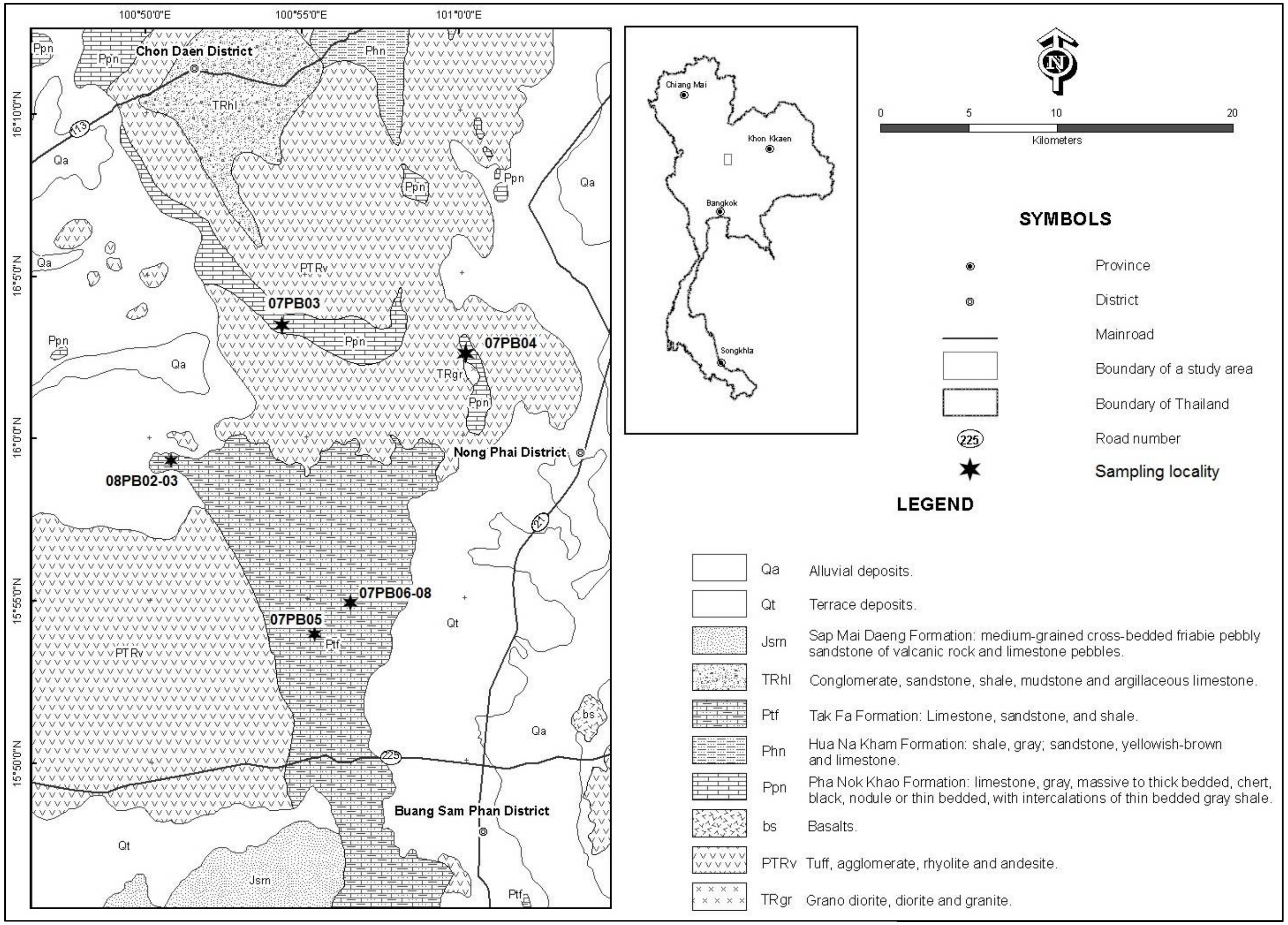

Figure 2.10 Geological map and sampling localities in the Phetchabun area

Figure 2.11 Lithologic log of Khao Kana section (07PB03) (left-see text for description), and photographs of the outcrop (right)

2.3.8 Nong Phai section (07PB04) (Figures 2.10 and 2.12)

A narrow strip of limestones is cropped out in an agricultural field on a small hill of the Ban Sub Heaw Moo village, at 100° 58' 59"E, 16° 01' 06"N, about 10 km west of Nong Phai District in Phetchabun Province. The outcrop is belonged to the Pha Nok Khao Formation (Chonglakmani and Sattayalak, 1979). The bedding attitude is N210/50° E. In the lower part, thin-bedded limestones are dark gray in colour, wackestones to packstones with fusulinids. In the upper part, limestones are medium-bedded showing wavy bedding, and are light gray in colour with coral fragments and crinoids stems. Seven limestone samples, 07PB04-1 to 07PB04-07 were collected from this location; thus, there are many ostracods recovered. Limestone sample numbers 07PB04-2 and 07PB04-5 were prepared for thin sections, and the presence of fusulinaceans *Sphaeroschwagerina*? sp. (Figure 2.7 I and J) suggests the Early Permian (Asselian to Sakmarian age). A sectioned ostracod carapace and limestone texture are shown on Plate 22, Figure 11.

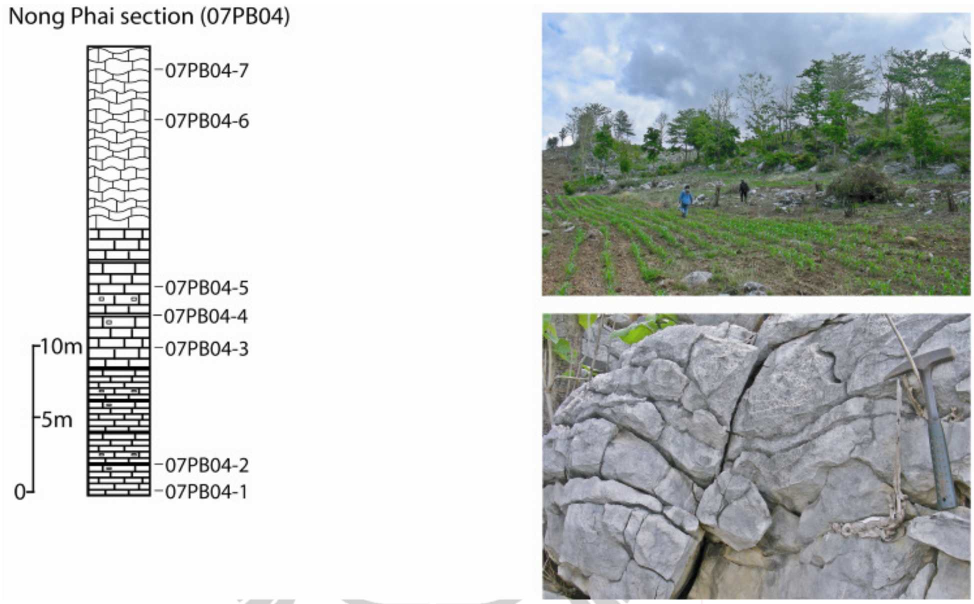

Figure 2.12 Lithologic log of Nong Phai section (07PB04) (left-see text for description), and photographs showing the limestone exposures in the agricultural field, and the wavy bedding structure (right)

2.3.9 Ban Naen Sawan I section (07PB05); (Figures 2.10 and 2.13)

Limestone outcrop is exposed at 100° 53' 36"E, 15° 54' 11"N, along the way to Ban Nean Sawan village which is about 18 km southwest of Nong Phai District, Phetchabun Province. It is belonged to the Tak Fa Formation (Nakornsri, 1977; 1981; Jeungyusuk and Kositanint, 1979). Medium-bedded limestones showing gentle dipping to the East (N140/25° E) are intercalated with shales. Limestones are dark gray, mudstones to wackestones with sparse gastropods and coral fragments. Seven limestone samples were collected from this section which yielded many ostracods.

Figure 2.13 Lithologic log of Ban Naen Sawan I section (07PB05) (left-see text for description), and photographs of the outcrop (right)

2.3.10 Ban Naen Sawan II section (07PB06-07PB08); (Figures 2.10 and 2.14)

The section is located about 15 km southwest of Nong Phai District in Phetchabun Province where 40 meter-high limestone hills are exposed in the agricultural land. This area is belonged to the Tak Fa Formation (Nakornsri, 1977, 1981; Jeungyusuk and Kositanont, 1979). Limestones are light gray, medium-to thick-bedded showing wavy bedding, and are mudstones to wackestones with sparse brachiopods, coral fragments, bryozoa and crinoids stems. Chert nodules are found through the section. Lower part of the section (07PB06, at 100° 55’ 46”E, 15° 55’ 08”N, Figure 2.14 lower-left), the bedding is N140/45° E. In the middle part (at 07PB07, Figure 2.14 middle-left), the bedding is N150/50° E where more chert nodules are found. In the upper part, at section (07PB08, at 100° 56’ 07”E, 15° 54’ 57”N, Figure 2.14 upper-left) the bedding is N135/50° E, where limestones are cropped out at the ground level. Along this 110 m-thick composited section, twenty one limestone samples were collected; few ostracods were recovered.

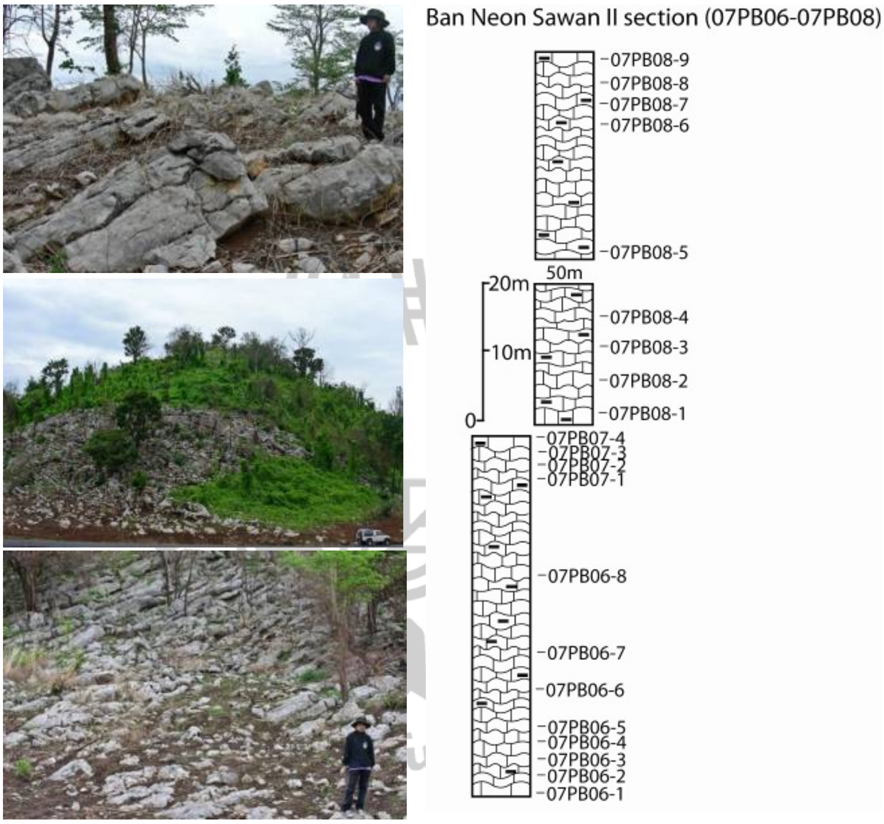

Figure 2.14 Lithologic log of Ban Naen Sawan II section (07PB06 to 07PB08) (right- see text for description), and photographs of the outcrops (left)

2.3.11 Phu Phra That section (08PB02-08PB03); (Figures 2.10 and 2.15)

The section is located about 22 km west of Nong Phai District in Phetchabun Province. Limestone outcrops are exposed in stream channels and excavated areas on the northwest side of the Khao Hin Kling mountain, and are belonged to the Tak Fa Formation (Nakornsri, 1977, 1981; Jeungyusuk and Kositanont, 1979). The overall section is more than 100 m thick which can be separated into the lower and the upper parts. The lower part (at 100° 52’ 21”E, 15° 58’ 22”N, Figure 2.15 lower-right) is about 15 m thick, and is intercalation of medium-bedded limestones and thin-to medium-bedded siltstones. Limestones are gray, wackestones to packstones with abundance of brachiopod carapaces and spines. The bedding attitude is N010/30° E. Then, there is soil-covered part which is about 80 m thick. The lower part of the upper part (about 20 m thick), located at 100° 53’ 3”E, 15° 57’ 53”N, is also the intercalation of medium-bedded limestones and thin-bedded siltstones, but siltstone beds here are thinner than those in the lower level. Brachiopods and bryozoans are abundant in the siltstone beds, normally as harden yellowish bedding surface. Brachiopods such as *Tyloplecta* sp., *Linoproductus* sp., and *Acosarina* sp. are typical of the Phetchabun fauna of Yanagida (1964) which suggests Middle Permian age (Sone, personal communication, July, 2008) The upper part of the section, there is a sequence of thin- to medium-bedded limestones showing wavy bedding with presence of chert nodules (Figure 2.15 upper-right). The limestones are gray, wackestones with sparse fusulinids and coral fragments. The bedding attitude of the upper part is about N300/20° E. Totally, eighteen limestone samples (08PB02-1 to 08PB02-13 and 08PB03-1 to 08PB03-6) were collected; few ostracods were recovered. Sample numbers 08PB02-9 and 08PB02-12 were prepared for thin sections; recovered fusulinaceans suggest early Middle Permian (Chareontitirat, personal communication, February, 2010). Thus, the early Middle Permian age is adopted for this section. A sectioned ostracod carapace and limestone texture are shown on Plate 22, Figure 12.

According to lithology and geological structure (bedding attitudes) of the study sections in the Phetchabun area, correlation between the study sections can be designated. The 07PB03 is overlain by the 07PB04; thus, both sections are of

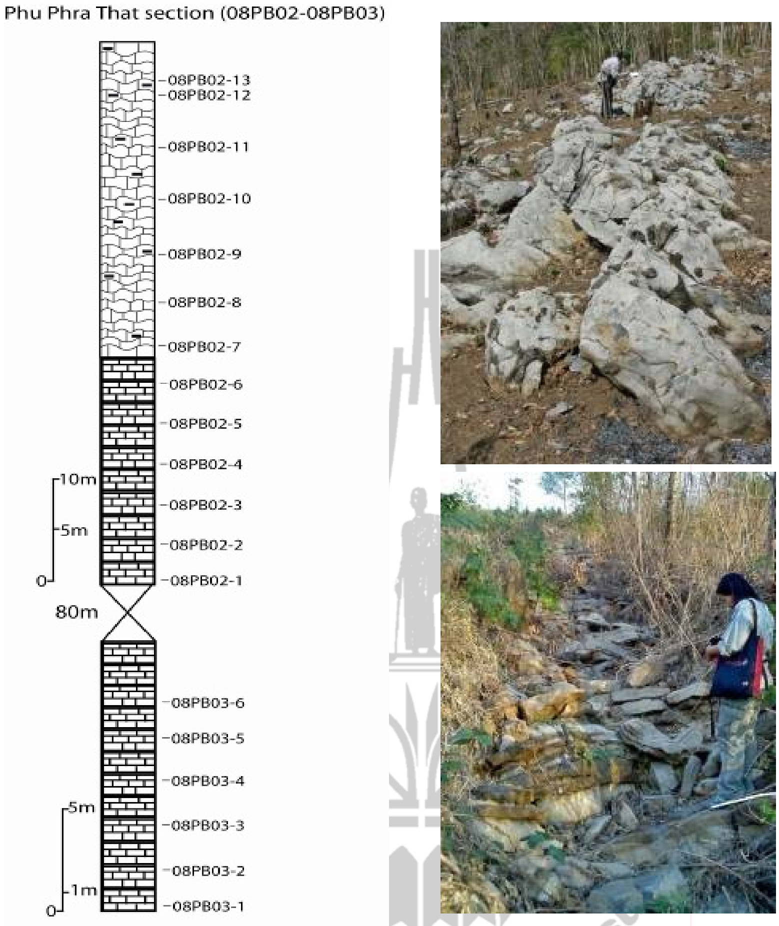

Figure 2.15 Lithologic log of the Phu Phra That section (08PB02 -08PB03) (left-see text for description), and photographs of the outcrops (right)

the Early Permian (the Asselian to Sakmarian age). The 07PB05 can be correlated to the lower part of the 08PB02 whereas the overlying 07PB06 to 07PB08 can be correlated to the upper part of the 08PB02 section; they are of early Middle Permian.

The Nakhon Sawan-Lopburi area (Figure 2.16)

2.3.12 Phu Lam Yai section (07LB04) (Figures 2.16 and 2.17)

The 07LB04 section is located at 100° 36’ 15”E, 15° 20’ 21”N, on the west side of a huge limestone mountain which is about 15 km north of Nong Muang District in Lopburi Province. This area is belonged to the Tak Fa Formation (Nakornsri, 1977;

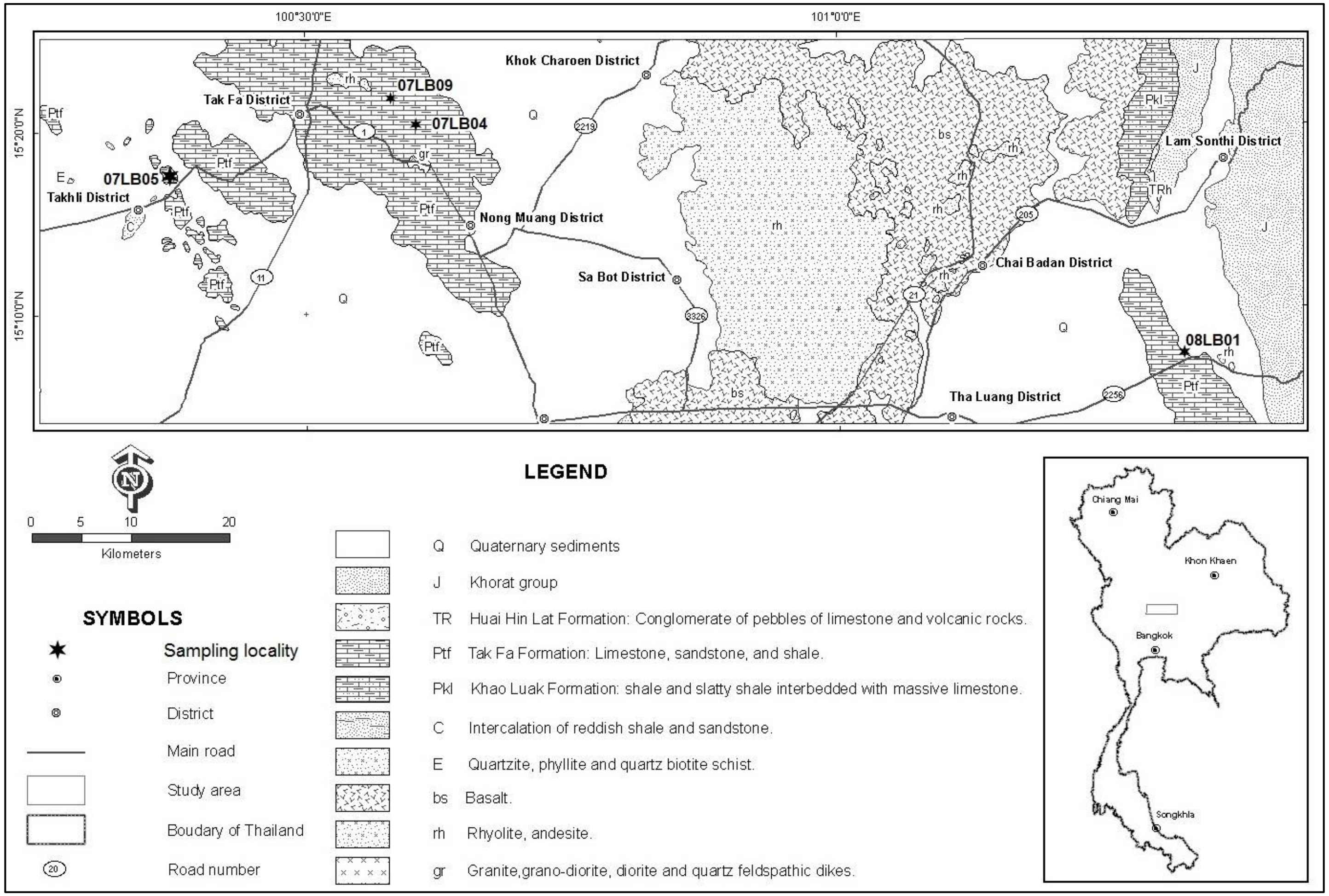

Figure 2.16 Geological map and sampling localities in the Nakhon Sawan-Lopburi area

Figure 2.17 Lithologic log of Phu Lam Yai section (07LB04) (left-see text for description), and photographs of the outcrop (right)

1981). Recently, Lower Kungurian conodonts (*Pseudosweetognathus costatus* and *Sweetognathus subsymmetricus)* were reported from the west side of the same mountain (Metcalfe and Sone, 2008). Thus the Kungurian age is adopted herein. The section of 30 m thick is comprised of intercalation of medium- to thick-bedded limestones and shales. Limestones are gray, mudstones to wackestones with sparse brachiopods in the upper part of the section. Totally, eighteen limestone samples were collected from this section; some ostracods were recovered.

2.3.13 Ta Kli section (07LB05); (Figures 2.16 and 2.18)

The section is an inactive quarry outcrop which located at 100° 22’ 46”E, 15° 19’ 05”N, about 3 km northeast of Ta Kli District in Nakhon Sawan Province. The outcrop is a part of the Tak Fa Formation (Nakornsri, 1977; 1981). The sequence of thin- to medium-bedded limestones intercalated with black shales. Limestones are

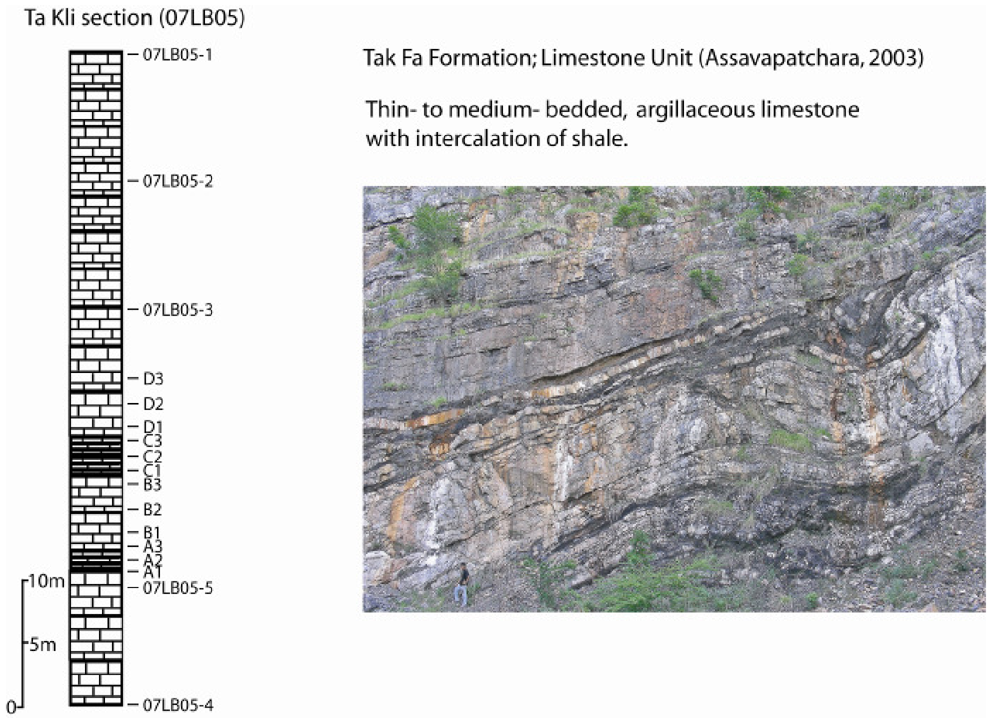

Figure 2.18 Lithologic log of Ta Kli section (07LB05) (left-see text for description), and photographs of the outcrop (right)

argillaceous, dark gray to very dark gray, wackestones with some bioclasts such as gastropods and small forams. Shales are black and rich of organic matters. This section may be correlated to Limestone Unit of Assawapatchara (2001, unpublished) which is composed of dark gray to black limestones, argillaceous limestones intercalated with laminated shales with chert nodules. According to Assawapatchara (2001, unpublished), the age of the rock unit is Middle Permian (probably Wordian). Several samples were prepared for thin sections, some small forams were recovered but without fusulinaceans. The section of about 30 m thick was measured, and twenty samples were collected. Many ostracods were recovered. A sectioned ostracod carapace and limestone texture are presented on Plate 22, Figure 13.

2.3.14 Khao Phu Chongkho locality (07LB09) (Figure 2.16 and 2.19)

The 07LB09 is located at 100° 35' 12"E, 15° 22' 45"N, about 20 km north of Nong Muang District of Lopburi Province. This locality is about 5 km north of the 07LB04 section which belonged to the Tak Fa Formation (Nakornsri, 1977; 1981) so, Early Permian (probably Kungurian) age is also adopted. At this location, medium-bedded limestones crop out, and limestones are light gray, wackestones to packstones with abundance of cephalopods, sponges and coral fragments. Some ostracods were recovered.

Figure 2.19 Photographs of the Khao Phu Chongkho locality showing thin- to medium-bedded limestones.

2.3.15 Khao Som Phot section (08LB01) (Figures 2.16 and 2.20)

The Khao Som Phot is a huge limestone range which is exposed in Lam Sonthi District of Lopburi Province. It is belonged to the Tak Fa Formation (Nakornsri, 1977; 1981), and is well known for a classic section of the Early to Middle Permian (Wielchowsky and Young, 1985). The 08LB01 section is located at 101° 31' 10"E, 15° 11' 16"N, at a small hill southeast of the Khao Som Phot, about 40 km west of Khok

Figure 2.20 Lithologic log of Khao Som Phot section (left-see text for description), and a photograph of the outcrop showing thick-bedded Alatochonchid bearing limestones (right).

Sam Rong District. Udchachon *et al*. (2007) made a detailed study on microfacies along a 70 m thick section. According to them, the late Middle Permian (Capitanian age) can be defined by fusuliniaceans (e.g., *Neoschwagerina* sp., *Colania* sp., *Lepidolina* sp.). Thus, the Capitanian age is adopted in this study. The limestones are thick-bedded, dark gray, mudstones to packstones. The measured section is at the base of the small hill, is about 15 m thick. The interesting associate fauna found along the section is giant bivalve *Alatochoncha* sp. (Udchachon *et al*., 2007). Six limestone samples were collected; they yielded some ostracods.

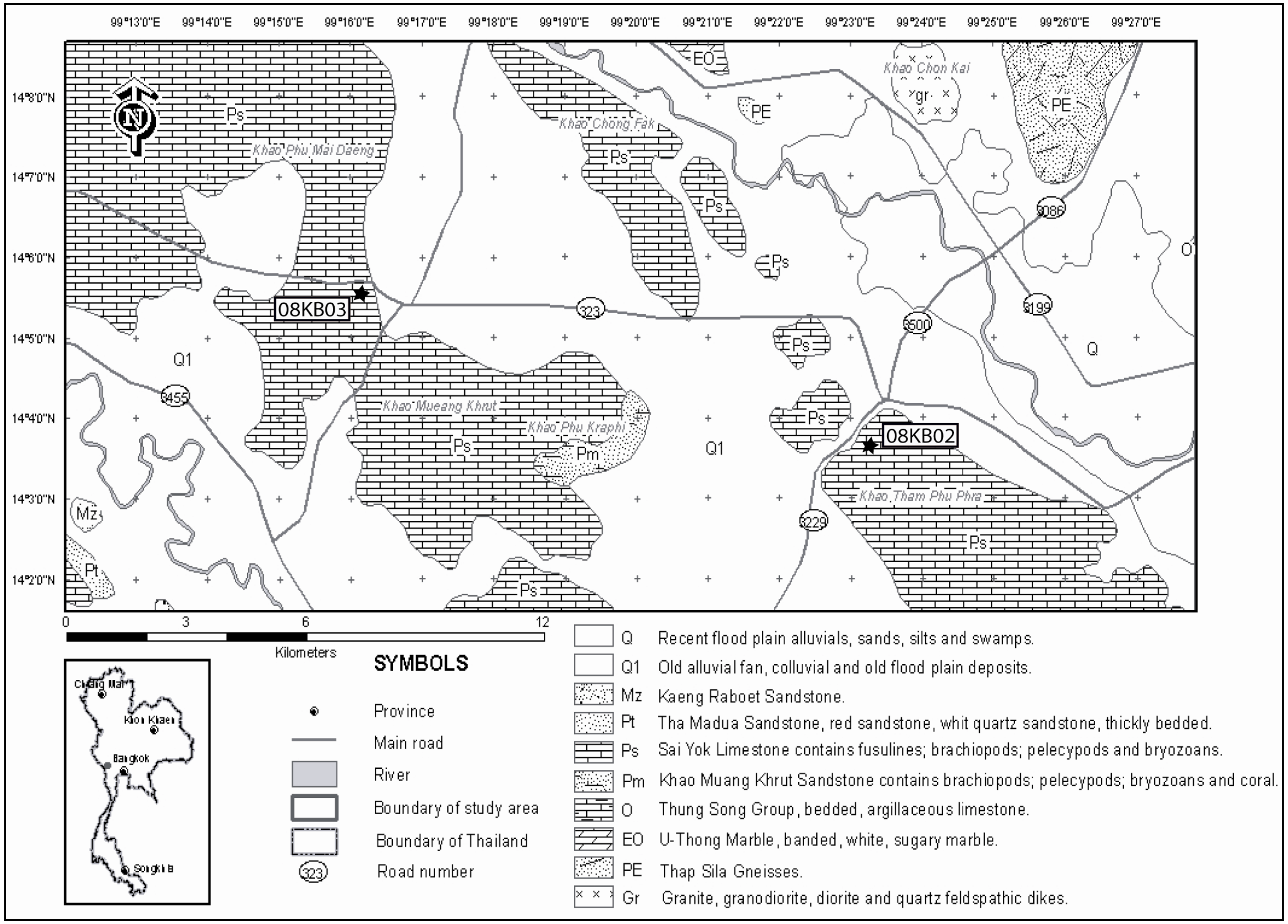

Figure 2.21 Geological map and sampling localities in the Kanchanaburi area

Figure 2.22 Photographs of Khao Pu Leab section

The Kanchanaburi area (Figure 2.21)

2.3.16 Khao Pu Leab section (08KB02) (Figure 2.21 and 2.22)

Khao Pu Leab is located about 15 km west of Kanchanaburi city. The rocks belong to the Sibumasu Block which were investigated by Chaodumrong *et al*. (2004; 2007). According to their work, three formations were designated, namely the Thung Nang Ling, the Phap Pha, and the Um Luk formations, in ascending order. Limestones of the Phap Pha formation can be indicated to Middle Permian (Wordian age) with reference to fusulinacean (*Yangchienia* sp.). The 08KB02 located at 99° 23' 13"E, 14° 03' 36"N (at the base of the mountain) was visited and seven limestone samples were collected. Nevertheless, they are barren of ostracods.

2.2.17 Ban Pu Pru section (08KB03) (Figures 2.21 and 2.23)

The section is located at Ban Pu Pru Primary school, at 99° 16' 10"E, 14° 05' 27"N, about 25 km west of Kanchanaburi city. Limestones exposed on the back yard of the school, forming a small hill of about 25 m high, were investigated. They are belonged to the Sai Yok Limestone of Bunopas (1981). The fusulinaceans such as *Eopolydiexodina* sp and *Pseudodoliolina* sp have been recovered at this locality which indicate Middle Permian age (Charoentitirat, personal communication, Fabruary, 2010). At this section, medium- to thick-bedded limestones with chert beds and nodules are oriented at N227/20°W. Limestones are cream to yellow, wackestones to packstones with sand-size allochems probably called calcarenite, and are locally dolomitized. At the top of the hill, there presence fossil bryozoans, corals and brachiopods. Several brachiopod fragments were tentatively identified as *Linoproductus* sp. indet. *sensu* Grant (1976) (Sone, personal communication, July, 2008). Nine limestone samples were collected along the 40 m thick section; two of them yielded few ostracods.

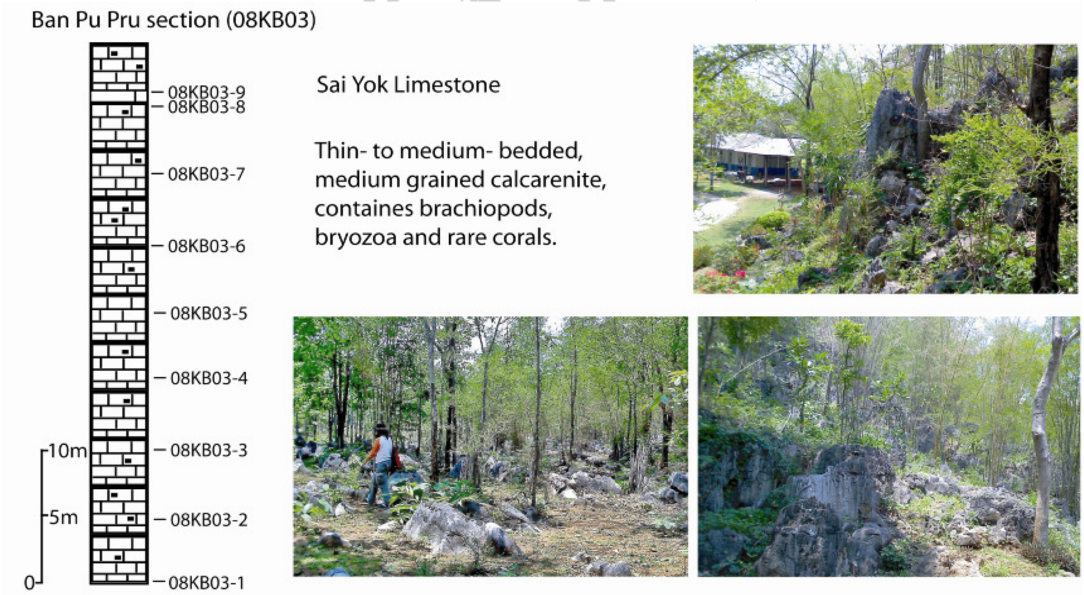

Figure 2.23 Lithologic log of Ban Pu Pru section (08KB03) (left-see text for description), and photographs of the outcrops (right)

CHAPTER III

SYSTEMATIC PALEONTOLOGY

Systematic paleonotology is the principal part of this dissertation; in other words, the recovered ostracods have to be classified and identified before the further applications. In order to understand the fauna, the generality of ostracods such as soft body structure, reproduction and ontogeny, and shell morphology are summarized in the first part of this chapter. Then in the second part, the classification used in this thesis is introduced. After that, methods of fossil ostracod preparation are explained. And finally, the systematics of the study ostracods is presented in the last part of the chapter.

3.1 Generality of ostracods

Ostracods are small crustaceans with the average size between 0.15 and 2.0 mm. In exceptional case, the giant species could reach 80 mm in length. They are one of the most diverse and abundant crustaceans who have lived on the Earth since the Ordovician; therefore, 33,000 species of the extant and extinct species have been recorded. The ostracods can live in almost all aquatic environments from freshwater to marine habitats (Armstrong and Brasier, 2005); besides, some of the living species are adopted to live in moisten soil or leaf litter. In micropaleontology, the ostracods play an important role in biostratigraphy, in determination of paleoenvironment and paleoclimate, and in dispensable as indicators of ancient shoreline and plate distribution.

3.1.1 Soft body structure (Moore, 1961; Pokorny, 1978; Armstrong and Brasier, 2005)

Appendages of the ostracods are paired and enclosed in a bivalve carapace which is hinged dorsally. The body is not obviously segmented, but can be divided to head and thorax. Therefore, the appendages or the jointed limb are evidences of segmentation. Four to five pairs of limbs arise from the head; which are, antennula and antenna (used for sensoring, swimming, feeding), mandibula and maxillula (used for feeding). The fifth limb or the first thoraxic limb is used for walking. The sixth and seventh limbs also called the second and third thoraxic limb (used for walking) arise from the thorax (Figures 3.1 A and B). There is a pair of furca near the posterior end. The ostracods have complete digestive tract including mouth, stomach, intestine and anus. The respiration is conducted by gills or certain appendages. The nerve system is poorly developed eyes are present in some species (Figure 3.1 C). The sex organs are paired and not connected. The female has ovaries, uteri, uterine opening, vaginae, and seminal receptacles. The male has tests, vasa deferentia, penes, and ejeculatory ducts.

The soft body is cover by cuticles connected to epidermis which secretes the carapace. The carapace consists of a calcified outer lamella and a uncalcified inner lamella. The internal organs are placed between the outer and inner lamella. The muscles running through the soft body and attaching the right and the left valves at the inner lamella which control the closure of the carapace are called adductor

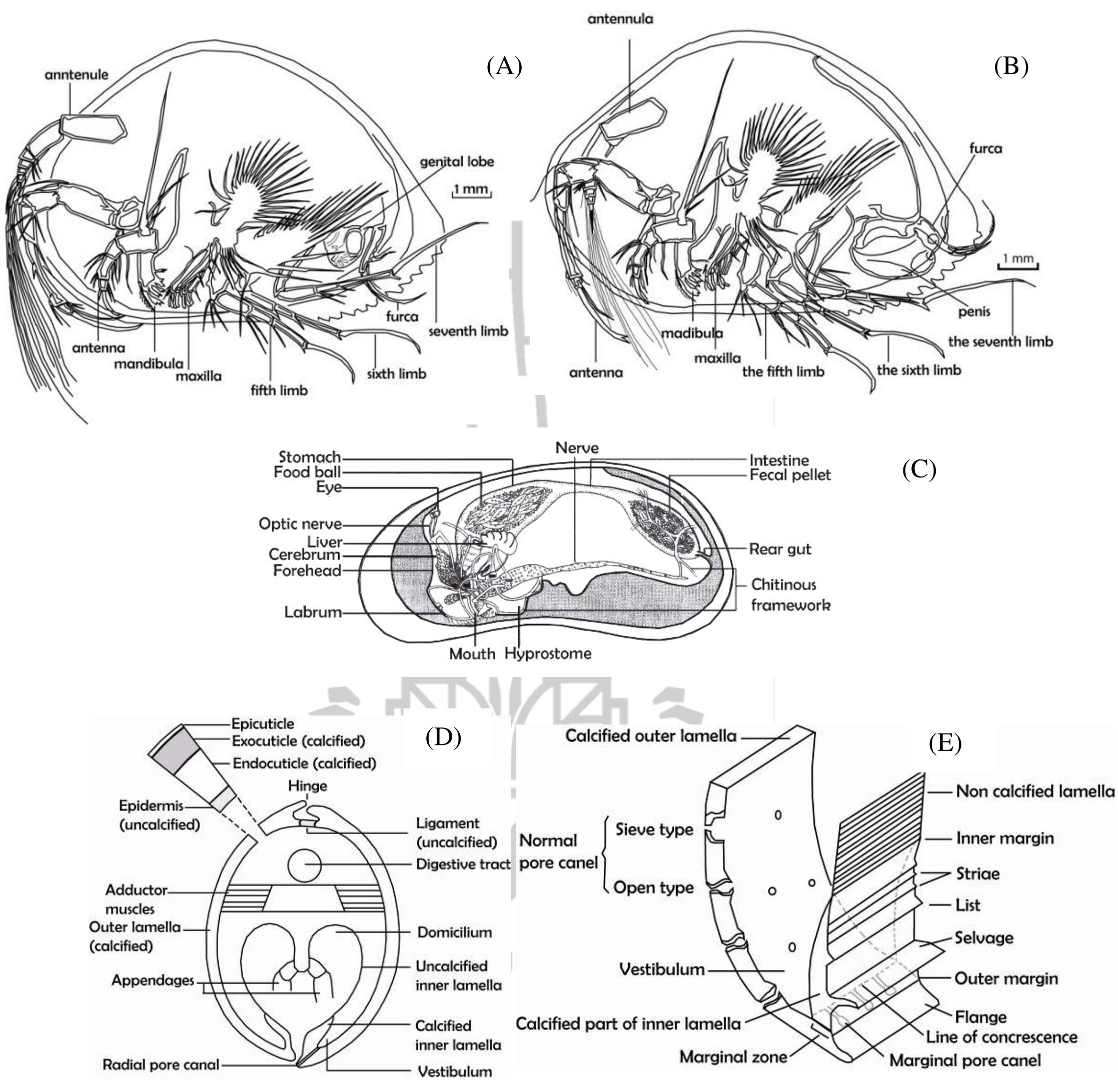

Figure 3.1 Sketches of ostracod soft body; (A) Morphology of a podocopid ostracod (Order Podocopida) *Bairdia frequens* G.W. Műller, Recent, female with left valve removed; (B) *Bairdia frequens* G.W. Műller, Recent, male with left valve removed; (C) soft-part anatomy of an ostracod; (D) transverse section through an ostracod; (E) section of the peripheral part of the podocopid ostracod valve. (Slightly modified after Moore, 1961; Armstrong and Brasier, 2005)

muscles. There are also other muscles which operate the appendages (Figure 3.1 D).

3.1.2 Reproduction and ontogeny

The ostracods have fundamentally a sexual reproduction, and can reproduce at any time of the year. In normal condition, the male inject spermatozoa into the female body resulting in fertilization of the eggs which are then either brooded in the carapace or laid onto the surroundings. In freshwater with absent of the male, the females are able to lay fertile female eggs, this process is called parthenogenesis. After hatching from the egg, the egg gives a nauplius which gives the first instar or larval stage. Young ostracods grow in discontinuous stages which is called instars. When the body of an instar is too large for its exoskeleton, the instar is moulted. There are usually eight to nine instars between the egg and the adult stage.

3.1.3 The ostracod carapace

The ostracod carapace is secreted by the epidermis. Like in other crustaceans, the cuticle is soft when it formed then becomes harden by a process called sclerotization. The left and right valves arise through the mineralization and are connected by a narrow strip of permanently soft cuticle called ligament. The left and right valves are connected by an adductor muscles running through the body and fixed to the inner surface of outer lamella (Figure 3.1 D).

Each valve consists of an outer and an inner lamella. The outer lamella is calcified and forms the outer surface of the valve and bend at the ventral margin into the inner lamella. The inner lamella is partly calcified and is connected to cuticles which cover the soft body. Internal organs are contained within space between the outer and the inner lamella. The ostracod is kept in touch with its surroundings by tactile bristles which penetrate the outer lamella through normal pore canals, marginal pore canals and sieve pores. An articulation or jointing of valves, called hinge, is developed in the dorsal margin of both valves (Figures 3.1 D and E).

3.2 Shell morphology of ostracod shell

Shell morphology is one of the criteria for ostracod classification, especially for the Paleozoic ostracods whose soft body is rarely preserved. External features including shape and size, ventral area, lateral surface and dorsal area have to be determined. Internal features such as muscle scars and hingement are essential for the fossil of younger age and are excluded here.

The outline or shape of an ostracod is possibly described as ovate, elliptical, or quadrate, etc. (Figure 3.2). The dorsal edge of carapace may be convex or straight, the ventral edge may be convex, straight, or concave. The anterior and posterior ends are usually round, but in some genera they may be elongate structure. The shape of the genus *Bairdia* is specific and termed the Bairdian shape (Figure 3.1 D). The maximum curvature may be located above or below mid-height. The area adjacent to hinge seen in dorsal view is dorsum (Figures 3.3 and 3.4). The juncture between dorsal border and ends are called the cardinal corners where the cardinal angles are measurable and can be useful in identification (Figure 3.2 C, *Kirkby* sp.2 in Figure 3.5). The position of greatest height controls the outline; if placed in front of the mid-length the carapace is referred as preplete, if placed at or near mid-length as amplete, if placed behind mid-length as postplete.

The area of valve unconcerned with hinge is the free margin including anterior and posterior ends and ventral edge (Figure 3.4). The length and height are measured from anterior to posterior ends and from dorsal to ventral edges of the

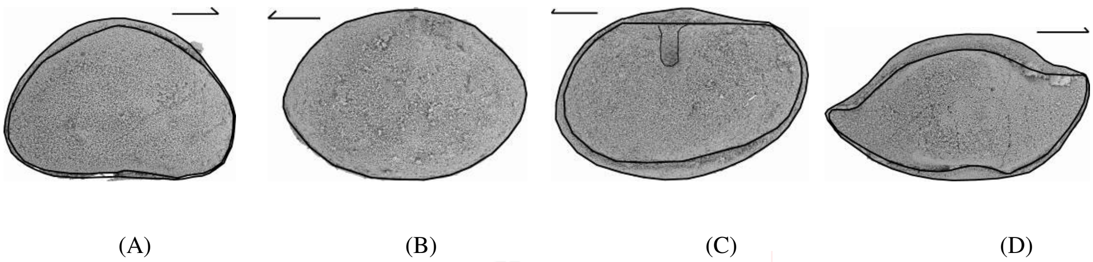

Figure 3.2 Examples of some selected ostracods from this research*

* (A) *Silenites* sp.2, right lateral view of the complete carapace, showing subtriangular outline, convex dorsal edge, concave ventral edge, round anterior and posterior ends, and maximum of curvature of both ends located below mid-height, wide overlap of left valve on right valve at dorsal and ventral borders; (B) *Microcoelonella* sp.2, left lateral view of the complete carapace, showing elliptic outline, amplete carapace, convex dorsal and ventral edges, round anterior and posterior ends, maximum of curvature of both ends located at mid-height, narrow overlap of right valve on left valve along the free margin; (C) *Sargentina* sp.2, left lateral view of the complete carapace showing subovate outline, straight dorsal edge, convex ventral edge, round anterior end with maximum convexity located below mid-height, and round posterior end with maximum convexity located above mid-height, anterior cardinal angle is of 135°, posterior cardinal angle is of 130°, wide overlap of right valve on left valve all around the carapace; (D) *Bairdia* sp.5, right lateral view of the complete carapace showing the Bairdian-shape outline, convex dorsal edge, concave ventral edge, tapering anterior end with maximum convexity located above mid-height, and tapering posterior ends with maximum convexity located at mid-height, incised dorsum, distinct overlap of left valve on right valve at dorsal border. Arrows point to the anterior direction.

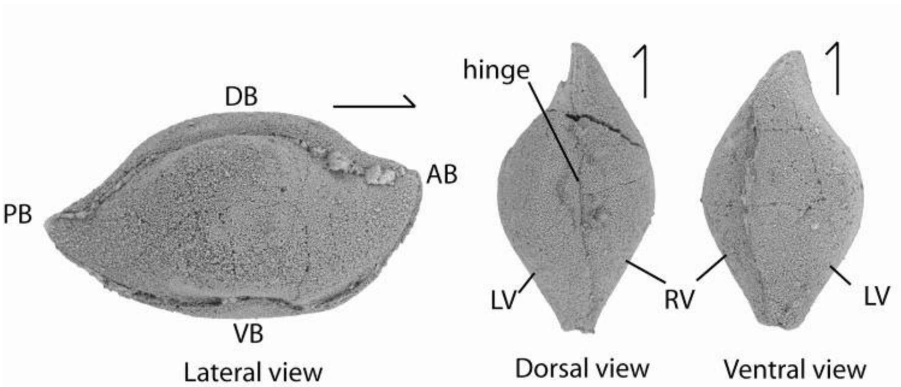

Figure 3.3 Carapace of the ostracods as seen on lateral, dorsal and ventral views (*Bairdia* sp.5).

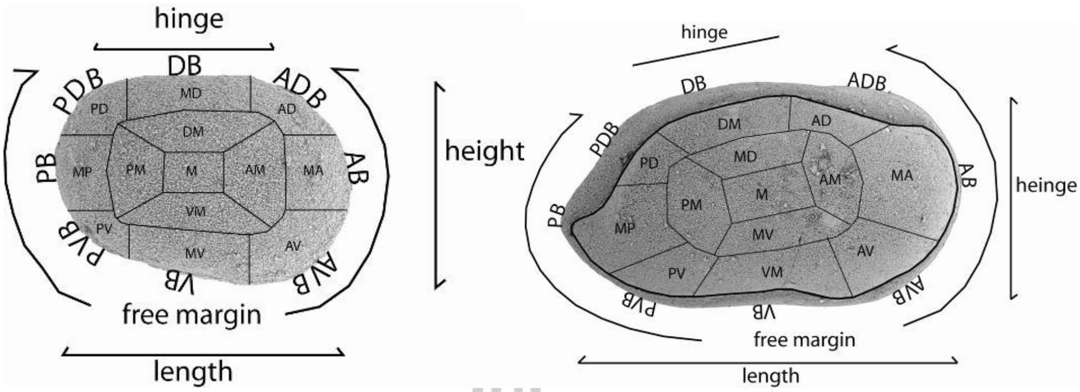

Figure 3.4 Features and nomenclature of the lateral surface, the examples on two selected ostracods from this thesis*

**Paraparchites* sp.1 (left) and *Bairdia* sp.19 (right); M : median; AM: anteromedian; MA: mid-anterior; PM: posteromedian; MP: mid-posterior; MD: dorsomedian; DM: mid-dorsal; MV: venterodorsal; MV: mid-ventral; AD: anterodorsal; AV: anterodorsal; PD: posterodorsal: PV; posteroventral. Terms such as DB: dorsal border; ADB: anterodorsal border; AB: anterior border; AVB: anteroventral border; VB: ventral border; PVB: posteroventral border; PB: posterior border; and PDB: posterodorsal.

carapace,respectively. The left and right valves are closed along the free margins. The overlapping between the larger and the smaller valves or the slight overlapping between the equal or subequal valves could be more or less important (Figure 3.2). In dorsal and ventral views, the carapace can be symmetric or asymmetric biconvex or quadrangular. Area adjacent to hinge called dorsum can be incised or unincised (Figure 3.3). The area adjacent to the ventral edge seen on ventral view is the venter (Figure 3.3). The structure extended from this part is referred as adventral which may be simple or modified by ridges, frills, or flanges (Figure 3.5).

The lateral surface of the ostracod valve is divided into anterior and posterior parts and into dorsal and ventral parts. The subdivision can be defined for specific

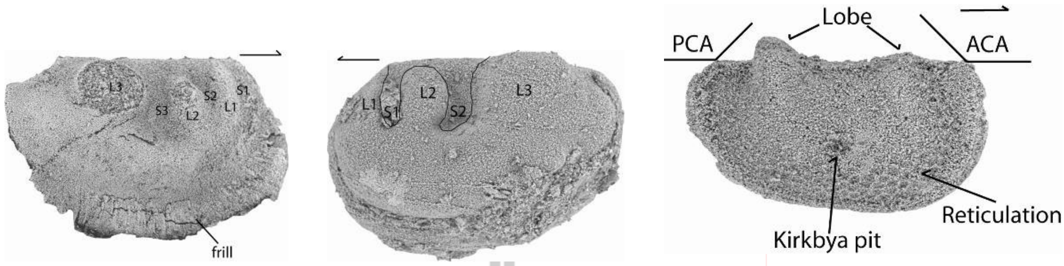

Figure 3.5 Some ornamentations of ostracod carapace, the examples of selected ostracods from this thesis*

* Lobes, sulci, and frill of *Hollinella (Hollina) herrickana* (Girty, 1909) (left); lobes and sulci of *Geisina* sp.2 (middle); lobe, median sulcus called Kirkbyan pit, and reticulation on the carapace suface of *Knigtina* sp.2 (right). Arrows points to anterior direction.

points on the carapace i.e., anterodorsal part (Figure 3.4). The valve surface may be smooth or ornamented; therefore, the ornamentation is one of the useful criterior for identification (*Kirkby* sp.2 in Figure 3.5). Lobes and sulci are distinctive features of many ostracod carapaces. The lobes represent elevations of the shell which are directly opposite internal depressions or the internal anatomy. The lobes have been designed numerically from anterior to posterior parts of the valve as L_1, L_2, L_3 and L_4. The sulci are elongate depressions of the domicilium labled as S_1, S_2 and S_3 from anterior to posterior parts (Figure 3.5). The sulci S_2 is reflecting the position of adductor muscle. In Kirkbyoidea S_2 is called Kirkbyan pit and is the distinct feature of the superfamily.

The reproductive system of the ostracod is well developed, the male and female have carapaces of different size and shape. The distinctive female forms, called heteromorphs, differ from the male and juvenile forms, called tecnomorphs, in having a more inflated posterior region, pronounce ventral lobes, round bulges such as brood, or wide frills. This sexual dimorphism has been recorded especially for the Order Palaeocopida; for instance, Kloedenellid dimorphism present in Kloedenellacea (Figure 3.6). Sexual dimorphism is less obvious in Order Podocopida but the males are generally longer and narrower and the females have greater posterior inflation.

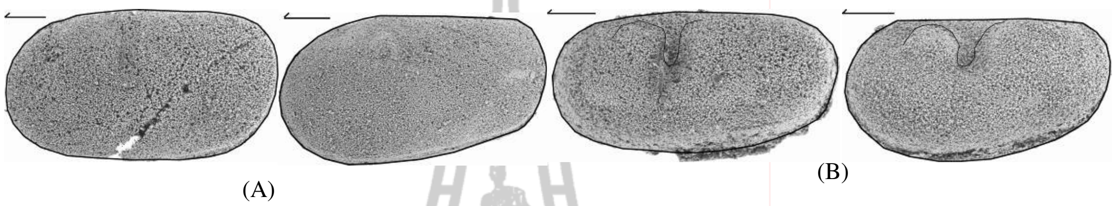

Figure 3.6 Kloedenellid dimorphism of ostracods observed in this research; (A) *Langdia* sp.1, heteromorph (left) has wider posterior portion than the tecnomorph (right); (B) *Geffenina* sp.2, heteromorph (left) and tecnomorph (right).

3.3 Classification

The classification of living ostracods is based on the morphology of the soft body, mainly on their appendages, and on other features such as shape and position of sex organs, presence of eyes and heart. In contrast, the classification of fossil ostracods is based primarily on features of the carapaces. The features which are valuable in classification of fossil taxa are such as 1) carapace shape, 2) nature, location and degree of overlap, 3) nature of dimorphism, 4) surface sculpture and nature of marginal zone. Other features for instance; 1) position and arrangement of muscle scar, 2) feature of normal and marginal pore canals, and 3) form of selvages and flanges are important for the post-Palaeozoic forms.

There are some disagreements for the higher classification of the Ostracoda which has been given the rank of subclass, class, or subphylum. In this thesis, the Ostracoda is accepted as a class of the subphylum Crustacea. According to the Treatise on Invertebrate Paleontology Part Q, the classification of Moore (1961) is primarily adopted herein.

The ostracods are divided into five orders Archaeocopida, Leperditicopida, Palaeocopida, Podocopida, and Myodocopida. Members of the last three orders are concerned to this thesis.

Order ARCHAEOCOPIDA (L.Cam.-M.Cam., ?U.Cam.-?L.Ord.)

Order LEPERDITICOPIDA (?U.Cam., L.Ord.-U.Dev.)

Order PALAEOCOPIDA (L.Ord.-M. Perm., ?Rec.)

Suborder BEYRICHICOPINA (L.Ord.-M.Perm.,?Rec.)

Suborder KLOEDENELLOCOPINA (L.Ord.-U.Jur.)

Order PODOCOPIDA (L.Ord.-Rec.)

Suborder PODOCOPINA (L.Ord.-Rec.)

Suborder METACOPINA (L.Ord., M.Ord.-L.Cret.)

Suborder PLATYCOPINA (Jur.-Rec.)

Order MYODOCOPIDA (Ord.-Rec.)

Suborder MYODOCOPINA (Ord.-Rec.)

Suborder CLADOCOPINA (?Dev., Miss.-Rec.)

3.4 Methods for fossil ostracod preparation (Lethiers and Crasquin-Soleau, 1988; Crasquin-Soleau *et al.*, 2005).

The fossil ostracods could be studied only with the external (and internal) features of the carapace. So, they have to be removed from the sediment. All the rocks studied here are very hard calcareous samples. A simple washing with water or Hydrogen peroxide is inefficient. The hot acetolysis method is used in this study. The concentrated acetic acid (CH_3COOH) is used in this process in which a laboratory or general purpose grade of reagent in suitable (all samples in this thesis were processed by using the 98% acetic acid). The method is as follows (Figure 3.7).

Step 1 Breaking. Each limestone sample (about 500 g) needs to be broken into small pieces in order to increase the surface exposing to the acid. In this step, a hammer and a block of steel are used. A container should be aware of contamination of the different samples. After breaking, the sample together with its clay-size matrix are poured into a well-label beaker.

Step 2 Dehydration. The sample is then dried in a hot-air oven at about 120° C for 24-48 hours. Dehydration should be complete to avoid acid attack of calcareous.

Step 3 Immersion. Once the sample is cooled to room temperature, carefully fill the concentrated acetic acid into the beaker until the sample is completely immersed. At this step, if effervescence occurs, it might be due to insufficient sample dehydration or impurity of acid. Cover the beaker with a household aluminium foil and cover (not seal) one more time with a lid.

Step 4 Heating. Place the beaker on a labolatory hot-plate, pre-set at 60° C. This process must be done in the fume cupboard.

Step 5 Chemical reaction. The sample is left for hours, but is periodically observed to be sure that it is immersed in acid. If not, fill the acid into the beaker. Observe the deposit of mud on the bottom of the beaker, the slowly developed cracks

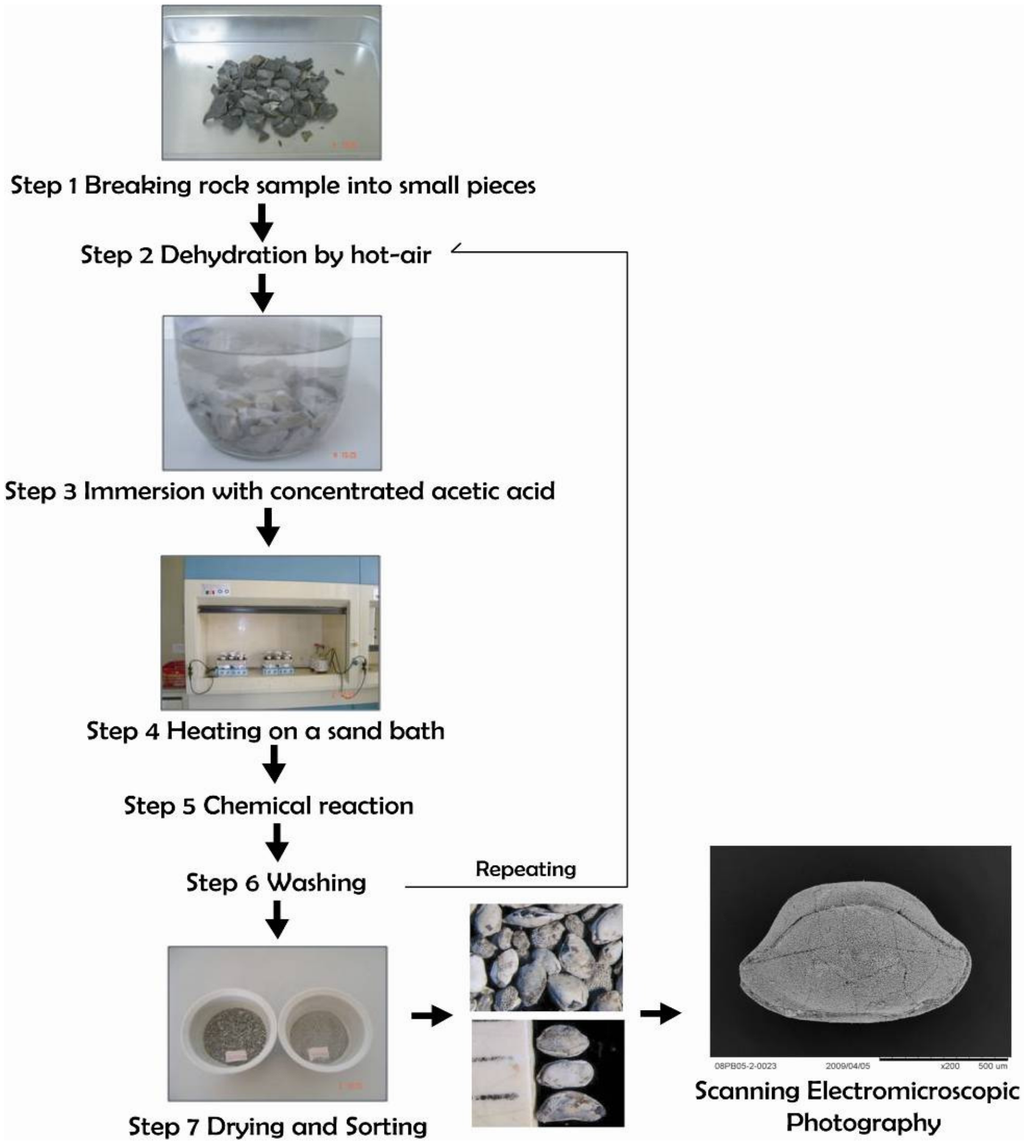

Figure 3.7 Diagram showing the technique of hot acetolysis (Lethiers and Crasquin-Soleau, 1988; Crasquin-Soleau *et al*., 2005) for fossil ostracod preparation.

and fracture on the large rock fragment, and the turning to yellowish brown colour of the acid. This step may take several hours, days to weeks. If there is no reaction, add some drops of water to initate a reaction.

Step 6 Washing. When disaggregation is complete, or is considered to generate sufficient material, pour off the acid through filter paper. The filtered acid can be reuse for this procedure. The residue must be washed rapidly through a stainless steel sieves (2 mm-63μm). The continuous flow of water is suitable for washing in order to reduce the dissolution effects of the acid due to dilution. In this step, be aware of acid by using plastic gloves, sleeve protectors, and eye protectors. The rock fragment remained on the 2 mm-size sieve is repeated from Step 2 (two acid immersions are required for each sample). The residues on the 1 mm-size sieve and the 63 μm are washed separately until no odour of acetic acid is detachable. Wash and drain the residues in the evaporating dishes.

Step 7 Drying. The residues are dried in the hot-air oven, and are cooled to the room temperature. The residues are to be sorted and are ready for microscopic study.

3.5 Systematic paleontology

In this thesis, 218 limestone samples were processed by the hot acetolysis technique (see section 3.4); as a result, 9,188 ostracod specimens were recovered and sorted. 2,323 specimens were photographed by scanning electron microscope, the SEM photographs were used in taxonomic study. The ostracod specimens were compared with previous publications of the Permian ostracods. Thus, there are 196 species belongeg to 41 genera, 15 families, and 9 superfamilies are recognized.

Abbreviations: L: length, H: height, W: width; AB: anterior border; VB: ventral border; PB: posterior border; DB: dorsal border; LV: left valve; RV: right valve; ACA: anterior cardinal angle; PCB: posterior cardinal angle.

Class OSTRACODA Latreille, 1802

Order PALAEOCOPIDA Henningsmoen, 1953

Suborder BEYRICHICOPINA Scott, 1961

Superfamily OEPILELLOIDEA Jaanusson, 1957

Family APARCHITIDAE Jones, 1901

Genus *Cyathus* Roth & Skinner, 1930

Type species: *Cyathus ulrichi* Roth & Skinner, 1930

Cyathus sp.1

Plate 16, Figures 8-12

Materials: 46 complete carapaces and 8 valves

Measurement: H=0.26-0.43 mm, L=0.44-0.73 mm, thickness=0.31-0.41 mm, H/L=0.54-0.60

Discussion: Specimens of genus *Cyathus* are easily recognized by small carapace, elliptical shape in lateral view, and inflation of median part. *Cyathus* sp.1 is characterized by its fine striation on carapace surface which is extending equally to dorsal and ventral outlines. In dorsal view, the carapace is long and subelliptical in shape. DB of both valves is convex and is higher than hinge. *C*. sp.1 can be compared to *C. caperata* (Guan, 1978) from Early Permian of Hunan, South China (Guan, 1978), but it can be differentiated from the latter species by having the more rectangular carapace in dorsal view.

Occurrences: Sample number 08LO07-1, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, northeastern Thailand, Early Permian; sample number 07PB04-2, 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07LB05-A1, 07LB05-A3, 07LB05-B2, 07LB05-D2, 07LB05-D3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Cyathus* sp.2**

Plate 16, Figures 13-16

Materials: 40 complete carapaces

Measurement: H=0.23-0.31 mm, L=0.52-0.61 mm, thickness=0.34-0.36 mm, H/L=0.52-0.61

Discussion: *Cyathus* sp.2 has fine striation on carapace surface which is extending equally to dorsal and ventral outlines. Carapace is long in lateral view, DB is slightly convex. In dorsal view the carapace is tumid and subrectangular in shape. *C*. sp.2 differs from *C*. sp.1 by its more slender carapace in lateral view. *C*. sp.2 is compared to *C. elliptica* Shi, 1987 from Latest Permian of Meishan section, South China (Shi and Chen, 1987) but it is different by more rectangular outline carapace in dorsal view.

Occurrences: Sample number 07PB04-2, 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07LB05-A1, 07LB05-A3, 07LB05-B2, 07LB05-D2, 07LB05-D3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Suborder KLOEDENELLOCOPINA Scott, 1961

Superfamily KLOEDENELLOIDEA Ulrich & Bassler, 1908

Family KNOXITIDAE Egorov, 1950

Genus *Knoxiella* Egorov, 1950

Type species: *Knoxiella semilukiana* Egorov, 1950

***Knoxiella* sp.1**

Plate 20, Figure 1

Materials: one complete carapace

Measurement: H=0.49 mm, L=0.66 mm, H/L=0.74

Discussion: This species is attributed to genus *Knoxiella* by presence of bulbous L_2 and small spine on postero-ventral part. *Knoxiella* sp.1 has distinct S_1, wide S_2, bulbous L_2 and L_3 with postero-ventral spines at both valves, and a wide overlap of RV on LV along free margins. The presence of postero-ventral spine recalls similarity with *K. ventrispinosa* Crasquin, 2008 from Late Permian of Bulla section, northern Italy (Crasquin *et al*., 2008b). However, the spine protrudes from VB of LV in *K. ventrispinosa* but it protrudes from postero-ventral border of LV in *K.* sp.1.

Occurrences: Sample number 07LB05-D1, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Knoxiella* sp.2**

Plate 20, Figures 2-3

Materials: two complete carapaces

Measurement: H=0.39-0.46 mm, L=0.71-0.79 mm, H/L=0.55-0.58

Discussion: *Knoxiella* sp.2 is characterized by subelliptical carapace, wide and shallow S_2, and moderate overlap of RV on LV along free margins. This species can be compared to *Knoxiella oblonga* Wang, 1978 from Early Triassic of Western Guizhou and northeastern Yunnan in China (Wang, 1978) in general appearance; however, the maximum convexity of PB in *K. oblonga* is located higher than that of *K.* sp.2.

Occurrences: Sample number 07PB03-5, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07PB05-6, Ban Naen Sawan section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Middle Permian.

Genus *Langdaia* Wang, 1978

Type species: *Langdaia suboblonga* Wang, 1978

***Langdaia* sp.1**

Plate 21, Figures 1-5

Materials: Nine complete carapaces

Measurement: H=0.34-0.42 mm, L=0.64-0.85 mm, H/L=0.46-0.56

Discussion: Species of genus *Langdaia* are characterized by straight DB, suboblong to subelliptical carapace in lateral view, presence of S_2 and absence of L_2. The specimens attributed to *Langdaia* sp.1 have suboblong carapaces, faint S_2 at mid length and smooth surface. Carapace is long and thin in dorsal view. Dimorphism is recognized by the wider posterior part of heteromorph. *L.* sp.1 is similar to *L. suboblonga* Wang, 1978 (Early Triassic of Western Guizhou and northeastern Yunnan, China) in lateral outline but it differs from the latter species by the faint S_2. At present, *L.* sp.1 cannot be compared to any known species.

Occurrences: Sample number 07LB04-13, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, late Early Permian; sample number 08LB01-3, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

Genus *Geisina* Johnson, 1936

Type species: *Beyrichiella gregaria* Ulrich & Bassler, 1906

Geisina sp.1

Plate 20, Figures 4-6

Materials: 13 complete carapaces and one valve

Measurement: H=0.37-0.40 mm, L=0.64-0.66 mm, H/L=0.56-0.61

Discussion: Species of genus *Geisina* are characterized by bisulcate carapace, incised hinge and presence of postero-dorsal spine. *Geisina* sp.1 has small spines protruded from the postero-dorsal part of both valves. S_1 and S_2 are long and narrow, L_2 and L_3 are presented. LV overlaps on RV along free margins. Sexual dimorphism is observed by inflation of ventromedian part in heteromorph. At present, this species cannot be compared to any known species.

Occurrences: Sample number 07PB03-3, Khao Kana section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian; sample number 07LB05-B1, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Genus *Eukloedenella* Ulrich & Bassler, 1923

Type species: *Eukloedenella umbilicata* Ulrich & Bassler, 1923

***Eukloedenella* sp.1**

Plate 20, Figure 7

Materials: one complete carapace

Measurement: H=0.40 mm, L=0.72 mm, H/L=0.56

Discussion: Presence of a single sulcus in anterodorsal half of both valves suggests the genus *Eukloedenella*. *Euklodenella* sp.1 is characterized by long and deep S_2. AB and PB are subvertical.

Occurrences: Sample number 08KB03-4, Ban Phu Pru section, Sai Yok Limestone, Kanchanaburi province, western Thailand, Middle Permian.

Eukloedenella sp.2

Plate 20, Figure 8

Materials: one complete carapace

Measurement: H=0.28 mm, L=0.49 mm, H/L=0.57

Discussion: The specimen recovered is attributed to genus *Euklodenella* with faint S_2 and smooth surface. ACA is sharp, PCA is not clear. *E.* sp.2 can be differentiated from *E.* sp.1 by wider ACA and PCA. AB and PB of *E.* sp.2 are round with the larger radius of curvature and maximum convexities located higher than those in *E.* sp.1.

Occurrences: Sample number 07LB05-B3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Eukloedenella? sp.1

Plate 21, Figures 7-9

Materials: four complete carapaces

Measurement: H=0.16-0.29 mm, L=0.30-0.57 mm, H/L=0.52-0.57

Discussion: *Euklodenella*? sp.1 is doubtfully attributed to the genus *Eukloedenella* by its general shape of carapace and faint S_2. AB is larger than PB, the greatest height is at or in front of mid length of the carapace.

Occurrences: Sample number 07LB09-1, Khao Phu Chongkho locality, Tak Fa Formation, Nakhon Sawan province, central Thailand, late Early Permian; sample number 08LB01-1, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

***Eukloedenella*? sp.2**

Plate 21, Figures 11-12

Materials: three complete carapaces

Measurement: H=0.16-0.25 mm, L=0.34-0.44 mm, H/L=0.49-0.57

Discussion: *Euklodenella*? sp. 2 is attributed with doubt to the genus by its general shape, and AB is wider than PB.

Occurrences: Sample number 07LB05-C1, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Eukloedenella*? sp.3**

Plate 21, Figures 14-15

Materials: five complete carapaces

Measurement: H=0.25-0.78 mm, L=0.45-1.54 mm, H/L=0.50-0.56

Discussion: *Euklodenella*? sp. 3 is attributed with doubt to the genus because of its general shape.

Occurrences: Sample number 07LB05-A1, 07LB05-B2, 07LB05-D2, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Genus *Sargentina* Coryell & Johnson, 1939

Type species: *Sargentina allani* Coryell & Johnson, 1939

Sargentina sp.1

Plate 20, Figures 9, 12, 15

Materials: eight complete carapaces and eight incomplete carapaces

Measurement: H=0.47-0.73 mm, L=0.76-1.13 mm, H/L=0.61-0.66

Discussion: The specimens are attributed to genus *Sargentina* by the important overlap of RV on LV all around the carapace, and with presence of S_2. *Sargentina* sp.1 is characterized by long and narrow S_2 at dorsomedian part of both valves. The overlap of RV on LV is maximum at DB and VB. Carapace surface is smooth to punctuate. At present, *S.* sp.1 cannot be compared to any known species.

Occurrences: Sample number 07PB03-3, 07PB03-07, Khao Kana section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian.

Sargentina sp.2

Plate 20, Figures 10-11, 13-14

Materials: ten complete carapaces

Measurement: H=0.44-0.57 mm, L=0.65-0.84mm, H/L=0.63-0.69

Discussion: *Sargentina* sp.2 has round and shallow S_2 in dorsomedian part of carapace. Carapace is short and tumid. By its shape and position of S_2, *S*. sp.2 cannot be compared to any known species.

Occurrences: Sample number 07PB03-3, 07PB03-07, Khao Kana section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian.

Genus *Geffenina* Coryell & Sohn, 1938

Type species: *Geffenina marmerae* Coryell & Sohn, 1938

***Geffenina* sp.1**

Plate 20, Figures 16-18

Materials: 118 complete carapaces and 13 incomplete carapaces

Measurement: H=0.36-0.49 mm, L=0.59-0.77 mm, H/L=0.52-0.63

Discussion: Trilobate, invaginated hinge without horizontal crest are the features of the genus *Geffenina*. *Geffenina* sp.1 is characterized by faint S_1, wide and faint S_2 in dorsomedian part of LV, faint and round L_2 and L_3. RV overlaps on LV along free magins. Dimorphism is recognized by the larger PB of heteromorph and inflation of postero-ventral part of the carapace. *G.* sp.1 is closed to *G. bungsamphanensis* Chitnarin, 2008 (Middle Permian of Tak Fa limestone from Phetchabun area, central Thailand), the more tumid carapace (the higher H/L ratio) and the wide and faint S_2 suggest the different species. Thus *G.* sp.1 cannot be compared to any known species.

Occurrences: Sample number 07PB03-1, 07PB03-3, 07PB03-5, 07PB03-07, Khao Kana section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian.

Geffenina sp.2

Plate 20, Figures 19-21

Materials: 13 complete carapaces

Measurement: H=0.30-0.37 mm, L=0.57-0.74 mm, H/L=0.48-0.55

Discussion: The specimens here are attributed to the genus *Geffenina* by their long carapaces, wide and long S_2 in dorsomedian part, round and faint L_2. Dimorphism is recognized by wider PB in heteromorphs. At present, *G.* sp.2 cannot be compared to any known species.

Occurrences: Sample number 07LB04-13, 07LB04-17, Khao Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, late Early Permian.

Genus *Kloedcytherella* Kozur, 1985

Type species: *Kloedcytherella oertlii* Kozur, 1985

Kloedcytherella oertlii Kozur, 1985

Plate 21, Figures 13, 16

1985 *Kloedcytherella oertlii* Kozur n.gen. n.sp. Kozur: 10, pl.2, figs.3-4

Materials: five complete carapaces

Measurement: H=0.23-0.24 mm, L=0.53-0.56 mm, H/L=0.42-0.44

Discussion: The specimens are not well preserved; however, such characters as general outline with flat marginal rim, and two horizontal ridges suggests *Kloedcytherella oertlii* Kozur, 1985 (Late Permian of Bűkk Mts., Hungary).

Occurrences: Bűkk Mountains, Hungary, early Late Permian (Kozur, 1985); sample number 08PB02-4, Phu Phra That section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Middle Permian; sample number 07LB04-14, 07LB04-10, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, late Early Permian; sample number 08LB01-1, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

Kloedenellidae indet.

Plate 21, Figures 6, 10

Materials: two complete carapaces

Measurement: H=0.74 mm, L=0.89 mm, H/L=0.83

Discussion: The specimens are attributed to Kloedenellidae by straight DB and faint median sulcus. Kloedenellidae indet. has subround carapace, straight hinge without invagination, and inflated mid-posterior part of both valves. At present, more precised determination cannot be made.

Occurrences: Sample number 08LO02-11, Tham Nam Maholan section, Nam Maholan Formation, Loei province, northeastern Thailand, Early Permian.

Suborder KLOEDENELLOCOPINA Scott, 1961

Superfamily PARAPARCHITOIDEA Scott, 1959

Family PARAPARCHITIDAE Scott, 1959

Genus *Paraparchites* Ulrich & Bassler, 1906

Type species: *Paraparchites humerosus* Ulrich & Bassler, 1906.

***Paraparchites* sp.1**

Plate 18, Figures 15-19

Materials: 12 complete carapaces and six incomplete carapaces

Measurement: H=0.37-0.83 mm, L=0.51-1.18 mm, H/L=0.66-0.76

Discussion: Nonsulcate, nonlobate, ovate to elongate-ovate carapace, broadly round AB and PB, ventral overlap narrow without overreach above hinge are the features of the genus *Paraparchites*. *P.* sp.1 can be recognized by shape of carapace, smooth suface, preplete carapace. LV overlaps on RV along free margins. Dimorphism may be recognized by the larger posterior part and the rounder carapace of the heteromorph. *P.* sp.1 is compared to juvenile specimens of *P. chenshii* Crasquin, 2010 from Latest Permian of Meishan section in South China (Crasquin *et al*., 2010: Plate 2, Figures 13-15) but differs by more rectangular carapace, and the maximum curvature of PB is located above mid height. There are subcircular specimens which similar to the adult of *P. chenshii* Crasquin, 2010 but in this study, they are attributed to genus *Samarella* by presence of overlap of RV on LV at DB (see *Samarella* sp.5).

Occurrences: Sample number 08LO01-3, Khao Tham Yai locality, Pha Nok Khao Formation, Phetchabun province, central Thailand, late Middle Permian; 08LO02-1, 08LO02-10, Tham Nam Maholan section, Nam Maholan Formation, Loei province, northeastern Thailand, Early Permian; sample number 07LB05-A1, 07LB05-D3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Paraparchitiidae sp.

Plate 19, Figures 2-3, 6

Materials: one complete carapace and two incomplete carapaces

Measurement: H=0.40 mm, L=0.62 mm

Discussion: This species is attributed to Paraparchitidae due to general appearance of lateral view. However, it shows the inverse heart-shape carapace in anterior and posterior views, ventral part of both valves are inflated, both valves are closed, contact margins are located above VB level. With the specific characters mentioned above, the specimens are similar to *Chamishaella*? sp. *sensu* Sohn, 1971 (Sohn, 1971: page A13, Plate 5, Figure 31) from late Mississipian of Alaska; although, the overreach of RV on LV is not observed in the studied specimens. Three specimens are recoverd, so it can not support the presence of sexual dimorphism of the family.

Occurrences: Sample number 07LB04-16, Khao Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, late Early Permian.

Genus *Shemonaella* Sohn, 1971

Type species: *Shemonaella dutroi* Sohn, 1971

Shemonaella sp.1

Plate 18, Figure 12

Materials: two complete carapaces

Measurement: H=0.58-0.68 mm, L=0.73-0.82 mm, H/L=0.80-0.83

Discussion: Unspined Paraparchitidae without incised dorsum nor overlap suggest the genus *Shemonaella*. *Shemonaella* sp.1 is characterized by subround carapace and smooth surface. At present, *S.* sp.1 cannot be compared to any known species.

Occurrences: Sample number 08LO02-2, Tham Nam Maholan section, Nam Maholan Formation, Loei province, northeastern Thailand, Early Permian.

Shemonaella sp.2

Plate 18, Figures 13-14

Materials: 13 complete carapaces and one incomplete carapace

Measurement: H=0.34-0.80 mm, L=0.53-1.25 mm, H/L=0.60-0.65

Discussion: *Shemonaella* sp.2 is characterized by long and preplete carapace which greatest height is located in front of mid length. *S.* sp.2 cannot be compared to any known species.

Occurrences: Sample number 07LB05-2, 07LB05-B3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Genus *Samarella* Polenova, 1952

Type species: *Samarella crassa* Polenova, 1952

***Samarella* sp.1**

Plate 17, Figures 17-19

Materials: six complete carapaces

Measurement: H=0.31-0.61 mm, L=0.40-0.86 mm, H/L=0.70-0.75

Discussion: Genus *Samarella* Polenova, 1952 (*Chamishaella* Sohn, 1971) refers to Paraparchitidae with overlap of LV on RV along free margins and overlap of RV on LV at DB. Herein *Samarella* sp.1 is characterized by hemicircular and flat carapace. AB is round with large radius of curvature, maximum convexity is located at mid height. PB is round but narrower than AB, maximum convexity is located above mid height. The overlap and overreach are present. *S.* sp.1 cannot be compared to any species known.

Occurrences: Sample number 07LB05-2, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian; sample number 07LB09-2, Khao Phu Chong Kho locality, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian.

Samarella sp.2

Plate 17, Figures 20-27, Plate 18, Figures 20-21

Materials: 36 complete carapaces

Measurement: H=0.36-0.85 mm, L=0.47-1.12 mm, H/L=0.72-0.81

Discussion: *Samarella* sp.2 is characterized by suboval carapace, AB is round with large radius of curvature and larger than PB. The maximum curvature of AB and PB are located at and higher than mid height, respectively. The overlap of RV on LV at DB is wide due to convex DB of RV and straight DB of LV. The overlap of LVon RV along the free margins is narrow. Sohn (1972) proposed the genus *Dorsoobliquella* for members of Paraparchitidae showing overreach above hinge with strongly convex DB and without spine. Some of the study specimens have convex DB on RV which suits the *Dorsoobliquella*; however, intraspecific characters have been observed among them. In my opinion, the genus *Samarella* is prefered, the *Dorsoobliquella* is subset of the former one. *S*. sp.2 differs from *S. meishanella* Crasquin, 2010 from Latest Permian of Meishan section, South China (Crasquin *et al*., 2010) by its distinct overlap of RV on LV at DB, narrow posterior part and PB located above mid height.

Occurrences: Sample number 07LB05-D2, 07LB05-D3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Samarella sp.3

Plate 18, Figures 1-6

Materials: 172 complete carapaces

Measurement: H=0.25-0.51 mm, L=0.37-0.69 mm, H/L=0.69-0.87

Discussion: *Samarella* sp.3 can be recognized by heart-shape carapace which ACA and PCA are raised above DB, and maximum convexity of VB is located at mid length. Changes in shape of carapaces within the study specimens are caused by H/L ratio and degree of rising of ACA and PCA which may be due to different stage of instars. This species can be compared to *S. victori* Crasquin, 2010 from Latest Permian of Meishan section, South China (Crasquin *et al*., 2010) but can be differentiated by its heart-shape carapace, AB is wider than PB and the maximum of curvature of both ends are located above mid height.

Occurrences: Sample number 08LO07-1, Sak Chai Quarry section, Pha Nok Khao Formation, Loei Province, northeastern Thailand, Early Permian; sample number 07PB04-2, 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian; sample number 07LB04-17, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, late Early Permian; 07LB09-1, Khao Phu Chongkho locality, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian; sample number 07LB05-A1, 07LB05-A2, 07LB05-A3, 07LB05-D2, 07LB05-D3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Samarella* sp.4**

Plate 18, Figures 7-8

Materials: seven complete carapaces

Measurement: H=0.38-0.45 mm, L=0.51-0.61mm, H/L=0.75-0.84

Discussion: *Samarella* sp.4 can be recognized by convec DB in anterior part and raised PCA. *S.* sp.4 is similar to *S.victori* Crasquin, 2010 from Latest Permian of Meishan section, South China (Crasquin *et al*., 2010: Plate 2, Figure 23 only) in round AB with obscured ACA. *S*.sp.4 differs from *S.victori* by maximum curvature of its AB is located above mid height. PB is narrower than AB, the maximum of curvature of PB is located higher than that in *S. victori*.

Occurrences: Sample number 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian; sample number 07LB09-1, 07LB09-2, Khao Chongkho locality, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian.

***Samarella* sp.5**

Plate 18, Figures 10-11

Materials: three complete carapaces

Measurement: H=0.47-1.07 mm, L=0.57-1.26 mm, H/L=0.81-0.84

Discussion: *Samarella* sp.5 has subcircular carapace and moderate overlap of RV on LV at DB. *S.* sp.5 can be compared to adult specimens of *Paraparchites chenshii* Crasquin, 2010 (Latest Permian of Meishan section, South-East China) but the overlap of RV on LV at DB is more important in *S*. sp.5. The carapace of *S*. sp.5 is very inflated in median part.

Occurrences: Sample number 07LB05-D2, 07LB05-D3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Genus *Shishaella* Sohn, 1971

Type species: *Shishaella nicklesi* Sohn, 1971

***Shishaella* sp.**

Plate 18, Figure 9

Materials: one right valve

Measurement: H=0.42 mm, L=0.60 mm, H/L=0.70

Discussion: The genus *Shishaella* can be recognized by a single spine on posterodorsal area of the smaller valve. *Shishaella* sp. has a posterodorsal spine located just behind mid length of RV. *S.* sp. is compared to *S. hunanensis* Guan, 1987 from Early Permian of Hunan Province in South China (Guan, 1987: Plate 36, Figure 6), but can be differentiated by the longer carapace and position of posterodorsal spine which is closer to mid length than that of latter species.

Occurrences: Sample number 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian.

Superfamily KIRKBYOIDEA Ulrich & Bassler, 1906

Family KIRKBYIDAE Ulrich & Bassler, 1906

Genus *Kirkbya* Jones, 1859

Type species: *Dithyrocaris permiana* Jones, 1850.

Kirkbya sp.1

Plate 19, Figure 4

Materials: one complete carapace

Measurement: H=0.33 mm, L=0.57 mm, H/L=0.59

Discussion: The genus *Kirkbya* can be recognized by its reticulated surface, straight DB which is the greatest length of the carapace, and presence of kirkbyan pit. *Kirkbya* sp.1 is characterized by a round kirkbyan pit in the median part of the carapace, and slightly concave VB. The specimen is not well preserved, *K*. sp.1 cannot be compared to any known species.

Occurrences: Sample number 07PB03-5, Khao Kana section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian.

Kirkbya sp.2

Plate 19, Figure 5

Materials: one complete carapace

Measurement: H=0.36 mm, L=0.55 mm, H/L=0.64

Discussion: *Kirkbya* sp.2 is classified to the genus due to presence of faint kirkbyan pit in ventero-median part of the carapace.

Occurrences: Sample number 07PB03-5, Khao Kana section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian.

Kirkbya sp.3

Plate 19, Figure 7

Materials: one incomplete carapace

Discussion: *Kirkbya* sp.3 is identified by lobes and a shallow kirkbyan pit on the ventral-median part of the carapace.

Occurrences: Sample number 08LO02-10, Tham Nam Maholan section, Nam Maholan Formation, Loei province, northeastern Thailand, Early Permian.

Genus *Knightina* Kellett, 1933

Type species: *Amphissites allorismoides* Knight, 1928

Knightina? sp.1

Plate 19, Figures 8-9

Materials: four complete carapaces

Measurement: H=0.21-0.31 mm, L=0.37-0.60, H/L=0.53-0.56.

Discussion: *Knightina*? sp.1 is characterized by obtuse ACA and PCA, well-developed posterior shoulder, and presence of marginal rim which suggest the genus *Knightina*. *K*.? sp.1 has subrectangular carapace, faint lobes, clear posterodrosal shoulder, and possibly two marginal rims. Preservation is not good enough for more precise identification.

Occurrences: Sample number 07LB05-C1, 07LB05-D2, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Knightina* sp.2**

Plate 19, Figure 10

Materials: one in complete carapace

Measurement: H=0.28 mm, L=0.52 mm, H/L=0.53

Discussion: *Knightina* sp.2 has suboblong carapace and posterodorsal shoulder. DB is shorter than the greatest length of carapace.

Occurrences: Sample number 07LB09-1, Khao Phu Chongkho locality, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian.

***Knightina* sp.3**

Plate 19, Figure 11

Materials: one incomplete carapace

Measurement: H=0.37 mm, L=0.76 mm, H/L=0.48

Discussion: *Knightina* sp.3 has subrectangular carapace, ACA and PCA are nearly 90 degree. Greatest length is located at DB, greatest height is located in front of mid length. This specimen is attributed to genus *Knightina* because kirkbyan pit is not observed. However, the posterodorsal shoulder which is a specific character of the genus is not presented in this specimen.

Occurrences: Sample number 08LO02-2, Tham Nam Maholan section, Nam Maholan Formation, Loei province, northeastern Thailand, Early Permian.

Knightina sp.4

Plate 19, Figures 12-15

Materials: 12 complete carapaces and seven incomplete carapaces

Measurement: H=0.19-0.45 mm, L=0.37-0.94 mm, H/L=0.41-0.53

Discussion: *Knightina* sp.4 is characterized by distinct posterodorsal lobe raised above DB, posterodorsal shoulder, and kirkbyan pit. *K.* sp.4 is compared to *K. hongfui* Crasquin, 2010 from Latest Permian of Meishan section in South China (Crasquin *et al*., 2010: page 10-11, Plate 1, Figures18-22, Figures 3R-U) in general appearance. A specific character of *K. hongfui*, a thin ridge on postero-ventral border and shoulder, is not observed in the studied specimens.

Occurrences: Sample number 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian; sample number 07PB08-2, Ban Naen Sawan II section, Tak Fa Formation, Phetchabun Province, Middle Permian; sample number 07LB05-B3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Genus *Reviya* Sohn, 1961

Type species: *Amphissites? obesus* Croneis & Gale, 1989

Reviya subsompongensis Chitnarin, 2008

Plate 19, Figures 16-17

2008 *Reviya subsompgensis* n.sp. Chitnarin. Chitnarin *et al*.: 347, figs.3(14-16)

Materials: seven incomplete carapaces

Measurement: H=0.37-0.41 mm, L=0.67-0.70 mm, H/L=0.55-0.59

Discussion: *Reviya subsompongensis* Chitnarin, 2008 is recognized by thick and smooth marginal rim and distinct postero-dorsal shoulder. The specimens recovered in this study are not well preserved and not abundant.

Occurrences: Tak Fa Formation, Bung Sam Phan district, Phetchabun Province, central Thailand, Middle Permian; sample number 08PB02-6, 08PB02-4, 08PB03-3, Phu Phra That section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Middle Permian.

Genus *Shleesha* Sohn, 1961

Type species: *Kirkbya pinguis* Ulrich & Bassler, 1906

Shleesha sp.

Plate 19, Figure 21

Materials: one incomplete carapace

Discussion: This species is attributed to genus *Shleesha* by presence of distinct median node.

Occurrences: Sample number 08PB02-3, Phu Phra That section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Middle Permian.

Family AMPHISSITIDAE Knight, 1928

Genus *Polytylites* Cooper, 1941

Type species: *Polytylites geniculatus*, Cooper, 1941

***Polytylites* sp.**

Plate 19, Figures 19-20

Materials: six complete carapaces and three incomplete carapaces

Measurement: H=0.31-0.46 mm, L=0.62-0.71 mm, H/L=0.51-0.53

Discussion: Species of Amphissitidae with presence of central node and shoulder suggests the genus *Polytylites*. *Polytylites* sp. can be recognized by distinct median node, kirkbyan pit below the node, and postero-dorsal shoulder. At present, *P.* sp. cannot be compared to anyspecies known.

Occurrences: Sample number 08LO07-1, 08LO07-8, Sak Chai Quarry section, Pha Nok Khao Formation, Loei Province, northeastern Thailand, Early Permian; sample number 07LB05-2, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Family KELLETTINIDAE Sohn, 1954

Genus *Kellettina* Swartz, 1936

Type species: *Ulrichia robusta* Kellett, 1933.

Kellettina **sp.**

Plate 19, Figure 18

Materials: two incomplete carapaces

Measurement: H=0.27-0.28 mm, L=0.47-0.56 mm, H/L=0.49-0.50

Discussion: This species is attributed to genus *Kellettina* due to absence of kirkbyan pit.

Occurrences: Sample number 07PB03-1, Khao Kana section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian; sample number 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian.

Superfamily YOUNGIELLOIDEA Kellett, 1933

Family YOUNGIELLIDAE Kellett, 1933

Genus *Permoyoungiella* Kozur, 1985

Type species: *Permoyoungiella bogschi* Kozur, 1985

Permoyoungiella **sp.**

Plate 21, Figures 17-19

Materials: four complete carapaces

Measurement: H=0.22-0.24 mm, L=0.49-0.50 mm, H/L=0.45-0.47

Discussion: The genus *Permoyoungiella* can be recognized by straight DB, small and elongate-oblong carapace, smooth or faintly reticulated surface. *Permoyoungiella* sp. shows the larger AB than PB, straight VB, narrow overlap of LV on RV at VB, and carapace flattened laterally.

Occurrences: Sample number 08LO02-2, Tham Nam Maholan section, Nam Maholan Formation, Loei province, northeastern Thailand, Early Permian; sample number 07PB04-2, 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian.

Superfamily HOLLINOIDEA Swartz, 1936

Family HOLLINELLIDAE Bless & Jordan, 1971

Genus *Hollinella* Coryell, 1928

Type species: *Hollinella dentata* Coryell, 1928

Hollinella martensiformis **Crasquin, 2010**

Plate 22, Figures 1-4

2010 *Hollinella martensiformis* Crasquin sp. nov. Crasquin *et al.*: 13, pl.2, figs.6-4, figs. 4D-F

Materials: 23 complete carapaces and three incomplete carapaces

Measurement: H=0.21-0.58 mm, L=0.37-1.06 mm, H/L=0.53-0.56

Discussion: The genus *Hollinella* has specific characters such as bilobate carapace and adventral structures. *Hollinella martensiformis* can be recognized by frill formed by a row of small tubercles along free margins and faint lobes. The studied specimens vary from small to large sizes compared to those found in Latest Permian of Meishan section in South China (Crasquin *et al*., 2010). The ACA and PCA are varied from 110°-130° and 110°-125°, respectively that is the smaller carapace has the smaller cardinal angles. *H. Martensiformis* can be differentiated from *H. martensi* Crasquin-Soleau, 1999 from Middle Permian of Oman Sultanate (Crasquin-Soleau *et al*., 1999) by the sharper ACA and PCA, and the fainter lobes.

Occurrences: Meishan section, South China, Latest Permian; sample number 07PB03-1, 07PB03-3, 07PB03-5, Khao Kana section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian; 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian; sample number 07LB04-8, 07LB04-10, 07LB04-12, 07LB04-17, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, late Early Permian; sample number 07LB09-1, Khao Phu Chongkho locality, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian; sample number 07LB05-A1, 07LB05-C1, 07LB05-D2, 07LB05-D3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Hollinella (Hollina) herrickana (Girty, 1909)

Plate 22, Figures 5-6

1909 *Hollinella (Hollina) herrickana* Girty nov. spec. Girty 1909: 115, pl.8, figs.10-11

1929 *Hollinella herrickana* [sic!] (Girty). Kellett: 197

?1930 *Hollinella herrickana* [sic!] (Girty). Delo: 156, pl.12, fig.4

1934 *Hollinella herrickana* [sic!] (Girty). Bassler & Kellett: 333

1943 *Hollinella herrickana* [sic!] (Girty). Kellett: 626

Non 1958 *Hollinella tuberculata* nov. spec. Gorak: 69 (nomen nudum)

?1965 *Hollinella tuberculata* nov. spec. (non Gorak, 1958). Belousova: 254, pl.46, figs.2a-c)

1972 *Hollinella (Hollinella) herrickana* (Girty, 1909). Bless & Jordan: 38-39

1989 *Hollinella (Hollina) herrickana* (Girty). Lethiers *et al*.: 230, pl.1, figs.2-4

1999 *Hollinella (Hollina) herrickana* (Girty). Crasquin-Soleau *et al*.: pl.2, fig.5

Materials: two incomplete valves

Measurement: H=0.471-0.684 mm, L=0.857-1.06 mm, H/L=0.55-0.64

Discussion: These specimens are attributed to *H. (H.) herrikana* by long and connecting L_1 and L_2, bulbous L_3 and velar structure.

Occurrences: Yeso Formation, New Mexico (U.S.A.), Lower Permian; Texas (U.S.A.), Late Carboniferous (Girty, 1909); Kaukasus (U.S.S.R.), ?Upper Permian (Belousova, 1965); Merbah el Oussif Unit, Jebel Tebaga, Tunisia, late Middle Permian (Lethiers *et al*., 1989); Harper Ranch beds of south-central British Columbia, Canada, Early Permian (Crasquin-Soleau and Orchard, 1994); Khuff Formation, Sultanate of Oman, Middle Permian (Crasquin-Soleau *et al*., 1999); sample number 07PB03-3, Khao Kana section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian.

Hollinella (Hollina) herrickana? (Girty), 1909

Plate 22, Figures 7-8

1909 *Hollinella (Hollinella) herrickana* Girty. Girty 1909:

Materials: two incomplete valves

Discussion: General appearance of both valves suggests the *H. (H.) herrickana*; however, the postero-dorsal spine on LV is unusual.

Occurrences: Sample number 07PB03-3, Khao Kana section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian.

Hollinella (Hollina)? sp.

Plate 22, Figure 9

Materials: one incomplete carapace

Measurement: H=0.31 mm, L=0.79 mm, H/L=0.63

Discussion: This specimen is attributed to *Hollinella* due to bulbous L_3 and possible adventral structure, but preservation is poor.

Occurrences: Sample number 08PB03-3, Phu Phra That section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Middle Permian.

Superfamily Unknown

Family COELONELLIDAE Sohn, 1971

Genus *Microcoelonella* Coryell & Sohn, 1938

Type species: *Microcoelonella scanta* Coryell & Sohn, 1938

***Microcoelonella* sp.1**

Plate 16, Figures 17-19

Materials: 107 complete carapaces and five incomplete carapaces

Measurement: H=0.29-0.38 mm, L=0.52-0.66 mm, H/L=0.56-0.58

Discussion: Subelliptical carapace, slightly convex DB with v-shape trough on DB, narrow overlap along the free margin are specific characters of the species *Microcoelonella* sp.1. *M*. sp.1 is compared to *M. longula* Chen, 1958 form Early Permian of Chisia Limestone at Nanking, south China (Chen, 1958); however, the studied specimens have less H/L ratio and narrower overlap of RV on LV alond free magins than the Chinese species. Sohn (1961) and Moore (1961) assigned genus *Microcoelonella* as synonym of *Paraparchites*, materials found in this study support that *Microcolonella* is a different genus which is perceived by specific generic characters. In 1971, Sohn proposed family Coelonellidae for the only genus *Coelonella* Stewart, 1936 which is characterized by small, asymmetrical, elongate carapace with channelled dorsum and broad ventral overlap. According to him, the studied specimens suit the genus *Coelonella* description; however, they are more similar to specimens of *Microcoelonella* as studied by Chen (1958).

Occurrences: Sample number 07LB05-2, 07LB05-A1, 07LB05-B1, 07LB05-B2, 07LB05-B3, 07LB05-D2, 07LB05-D3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Microcoelonella sp.2

Plate 16, Figures 20-25

Materials: 33 complete carapaces and three incomplete carapaces

Measurement: H=0.34-0.48 mm, L=0.49-0.67 mm, H/L=0.63-0.74.

Discussion: *Microcoelonella* sp.2 can be differentiated from *M*. sp.1 by the higher H/L ratio and the more convex DB.

Occurrences: Sample number 07LB05-A1, 07LB05-B1, 07LB05-B2, 07LB05-B3, 07LB05-D2, 07LB05-D3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Microcoelonella? sp.

Plate 16, Figures 26-29

Materials: 28 complete carapaces and four incomplete carapaces

Measurement: H=0.27 mm, L=0.43-0.50 mm, H/L=0.54-0.62.

Discussion: The specimens here are attributed to *Microcoelonella* with doubt because of absence of v-shape trough on DB. *Microcoelonella?* sp. is compared to *Microcoelenella* sp. described by Chen (1958) from Early Permian of Kwanshan and Lungtan sections, Chihsia Limestone, Nanking Province, South China (Chen, 1958).

Occurrences: Sample number 07LB05-A1, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Order PODOCOPIDA Müller, 1894

Suborder PODOCOPINA Sars, 1866

Superfamily BAIRDIOIDEA Sars, 1888

Family BAIRDIIDAE Sars, 1888

Genus *Bairdia* McCoy, 1844

Type species: *Bairdia curta* McCoy, 1844.

***Bairdia mianyangensis* Chen, 1982**

Plate 1, Figures 1-3

1982 *Bairdia*? *mianyangensis* Chen sp. nov. Chen & Shi: 123, pl.4, figs.14-18

1987 *Bairdia*? *mianyangensis* Chen. Shi & Chen: 38, pl.2, fig. 20

Materials: four complete carapaces and three incomplete carapaces

Measurement: H=0.469-0.641 mm, L=0.61-1.11 mm, H/L=0.57-0.58

Occurrence: Nantong section, Jiangsu Province, Latest Permian (Chen and Shi, 1982); Meishan section, Changxing, Zhejiang, South China, Latest Permian (Shi and Chen, 1987); sample number 07PB03-1 and 07PB03-3 Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, Early Permian.

Bairdia guangxiensis Guan, 1978

Plate 1, Figures 4-6

1978 *Bairdia guangxiensis* Guan (sp. nov.). Guan *et al*.: 154, pl.38, figs.3-4

1982 *Bairdia guangxiensis* Guan. Chen & Shi: 122, pl.5 fig.17

1986 *Bairdia guangxiensis* Guan. Chen & Bao: 114, pl.3, figs.7-8

1987 *Bairdia guangxiensis* Guan. Shi & Chen: 31, pl.3, figs.1-9

2002 *Bairdia guangxiensis* Guan. Shi & Chen: 67, pl.5, figs.1-9, pl.28, figs.1-2

Materials: two complete carapaces and 14 incomplete carapaces

Measurement: H=0.547-0.838 mm, L=0.826-1.180 mm, H/L=0.66-0.71

Discussion: *Bairdia guangxiensis* can be easily recognized by presence of ventral beak and flat ventrum.

Occurrence: Wugang, Hunan Province, Early Permian (Guan *et al*., 1978); Nantong section, Jiangsu Province, Latest Permian (Chen and Shi 1982); Well-Bao-1, Chihsia Limestone, Jiangsu Province, Early Permian (Chen and Bao 1986); Meishan section, Changxing, Zhejiang, South China, Latest Permian (Shi and Chen, 1987); Matan and Pingding sections, Guangxi. South China, Late Permian (Shi and Chen 2002); sample number 07PB06-3, 07PB07-4 and 07PB08-2, Ban Naen Sawan II section, Tak Fa Formation, Phetchabun Province, Middle Permian.

Bairdia bassoni Crasquin, 2010

Plate 1, Figures 7-8

1982 *Bairdia radlerae* Kellett. Chen & Shi: 121, Pl.4, figs.9-10, pl.5, fig.16

1987 *Cryptobairdia* cf. *compacta* (Geis). Shi & Chen: 44, pl.5, fig.1

2010 *Bairdia bassoni* Crasquin (sp. nov.). Crasquin *et al*.: 24, pl.7, figs.25-26, 29-32

Materials: eight complete carapaces

Measurement: H=0.364-0.529 mm, L=0.617-0.930 mm, H/L=0.56-0.58

Occurrence: Nantong section, Jiangsu Province, Latest Permian (Chen and Shi 1982); Meishan section, Changxing, Zhejiang, South China, Latest Permian (Shi and Chen, 1987); Meishan section, South China, Latest Permian (Crasquin *et al*., 2010); sample number 07PB03-3, Khao Kana section, Pha Nok Khao Formation, Phetchabun province, Early Permian.

***Bairdia girtyi* Sohn *sensu* Chen & Bao, 1986**

Plate 1, Figures 9-10

1986 *Bairdia girtyi* Sohn. Chen & Bao: 115, pl.2, figs.6-7

Materials: seven complete carapaces

Measurement: H=0.459-0.602 mm, L=1.070-1.050 mm, H/L=0.42-0.44

Occurrence: Well-Bao-1, Chihsia Limestone, Jiangsu Province, Early Permian (Chen and Bao 1986); sample number 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian; sample number 07LB05-4, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Bairdia lungtanensis* Chen, 1958**

Plate 1, Figures 11-13

1958 *Bairdia lungtanensis* Chen (sp. nov.). Chen: 224, pl.4, figs.1-8

Materials: five complete carapaces

Measurement: H=0.39-0.75 mm, L=0.71-1.40 mm, H/L = 0.51-0.54

Ocurrence: Kwanshan and Lungtan sections, Chihsia Limestone, Nanking Province, Early Permian (Chen, 1958); sample number 07PB03-7, Khao Kana section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian; sample number 07LB05-1, Ta Kli section, Tak Fa Formation, Middle Permian, Nakhon Sawan province, central Thailand; sample number 08LO02-9 and 08LO02-11, Tham Nam Maholan section, Nam Maholan Formation, Loei province, northeastern Thailand, Early Permian.

***Bairdia subleguminoides* Chen, 1987**

Plate 1, Figures 14-16

1987 *Bairdia subleguminoides* Chen sp. nov. Shi & Chen: 39, pl.3, figs.14-16

2002 *Bairdia subleguminoides* Chen. Shi & Chen: 68, pl.6, figs.3-7

2010 *Bairdia subleguminoides* Chen, 1987. Crasquin *et al.*: 26, pl.7, figs.5-6, figs.7E-F

Materials: six complete carapaces and one incomplete carapace

Measurement: H=0.33-0.60 mm, L=0.68-1.10 mm, H/L=0.48-0.50

Occurrence: Wugang, Hunan Province, Early Permian (Guan *et al*., 1978); Matan and Pingding sections, Guangxi, South China, Late Permian (Shi and Chen, 2002); Meishan section, Zhejiang Province, South-East China, Latest Permian (Crasquin *et al*., 2010) ; sample number 07PB05-3, Ban Naen Sawan I section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian; sample number 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Middle Permian; sample 07LB05-A2, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Bairdia urodeloformis* Chen, 1987**

Plate 1, Figures 17-18

1987 *Bairdia macdonelli* Harlton. Shi & Chen: 25, pl.1, figs.1-7, pl.18, figs.1-4

1987 *Bairdia urodeloformis* Chen sp. nov. Shi & Chen: 40, pl.4, figs.17-23

2002 *Bairdia urodeloformis* Chen. Shi & Chen: 63, pl.2, figs.1-4

2010 *Bairdia urodeloformis* Chen, 1987. Crasquin *et al*.: 24, pl.7, figs.7-14, figs.7G-N

Materials: two complete carapaces

Measurement: H=0.25-0.51 mm, L=0.54-1.25 mm, H/L=0.41-0.46

Occurrence: Meishan section, Zhejiang Province, Late Permian (Shi and Chen, 1987); Matan and Pingding sections, Guangxi, South China, Late Permian (Shi and Chen, 2002); Meishan section, South China, Latest Permian (Crasquin *et al*., 2010); sample number 07LB05, Ta Kli section, Tak Fa Formation, Nakhon Sawan province, central Thailand, Middle Permian

Bairdia cf. _urodeloformis_ Chen, 1987

Plate 1, Figures 19-22

Materials: 12 complete carapaces

Measurement: H=0.22-0.45 mm, L=0.63-1.05 mm, H/L=0.34-0.43

Discussion: The specimens are compared to *Bairdia urodeloformis* Chen, 1987 from Late Permian of Meishan section, South China (Shi and Chen, 1987) by having long and flat carapace with acute AB and tapering PB. DB is straight but is convex in *B. urodeloformis*.

Occurrence: Sample number 07LB05-A1, 07LB05-B2 and 07LB05-B3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian; Sample number 08LO02-2, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, northeastern Thailand, Early Permian.

Bairdia cf. _calida_ Chen, 1958

Plate 2, Figures 12, 15

Materials: one complete carapace and two incomplete carapaces

Measurement: H=0.715-0.747 mm, L=1.22-1.33 mm, H/L=0.56-0.58

Discussion: The specimens here are compared to *Bairdia calida* Chen, 1958 from Early Permian of Chihsia Limestone, South China (Chen, 1958) but such characters as a narrow dorsal ridge on LV and a narrow ventral ridge on RV are not obvious.

Occurrence: Sample number 07PB03-7, Khao Kana section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Early Permian; sample number

07PB05-3, Ban Naen Sawan I section, Pha Nok Khao Formation, Phetchabun province, central Thailand, Middle Permian.

***Bairdia beedei* Ulrich & Bassler, 1906**

Plate 2, Figures 16-18

1906 *Bairdia beedei* Ulrich & Bassler sp. nov. Ulrich & Bassler: 161, pl.11, figs.19-20

1934 *Bairdia marmorea* Kellett sp. nov. Kellett: 127, pl.15, figs.1a-h

1958 *Bairdia beedei* Ulrich & Bassler. Chen: 249, pl.5, figs.1-4

Materials: five complete carapaces

Measurement: H=0.49-0.86 mm, L=0.82-1.13 mm, H/L=0.54-0.57

Occurrence: Cotton wood shale, Kansas, Pennsylvanian (Ulrich and Bassler, 1906); Wreford formation, Chase Country, Kansas, Pennsylvanian (Kellett, 1934); Kwanshan and Lungtan sections, Chihsia Limestone, Nanking Province, Early Permian (Chen, 1958); sample number 07PB03-1, 07PB03-7, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

***Bairdia zhongyingensis* Wang, 1978 *sensu* Chen & Bao, 1986**

Plate 2, Figure 19

1986 *Bairdia zhongyingensis* Wang, 1978. Chen & Bao: 115, pl.3, fig.13

Materials: one complete carapace

Measurement: H=0.712 mm, L=1.31 mm, H/L=0.54

Occurrence: Chihsia Limestone, Jiangsu Province, South China, Early Permian (Chen and Bao 1986); sample number 07LB05-A2, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Bairdia trianguliformis* Chen, 1958**

Plate 2, Figures 20-21

1958 *Bairdia trianguliformis* Chen (sp. nov.). Chen: 6, pl.6, figs.9-12

1982 *Bairdia trianguliformis* Chen. Chen & Shi: 121, pl.6, figs.9-12

2002 *Bairdia trianguliformis* Chen. Shi & Chen: 66, pl.4, figs.3-9

Materials: two complete carapaces and three incomplete carapaces

Measurement: H=0.61-0.89 mm, L=1.19-1.79 mm, H/L=0.48-0.50

Discussion: The wide overlap of RV on LV at DB is the specific character of *Bairdia trianguliformis* Chen, 1958 from Early Permian of Chihsia Limestone, South China (Chen, 1958).

Occurrence: Kwanshan and Lungtan sections, Chihsia Limestone, Nanking Province, Early Permian (Chen, 1958); Nantong section, Jiangsu Province, Latest Permian (Chen and Shi, 1982); Matan and Pingding sections, Guangxi, South China, Late Permian (Shi and Chen, 2002); sample number 07LB05-B1 and 07LB05-C3, Ta Kli section, Tak Fa Formation, Nakhon Sawan province, central Thailand, Middle Permian; sample number 08LO02-9, Tham Nam Maholan section, Nam Maholan Formation, Loei province, northeastern Thailand, Early Permian; sample number

08LO07-1 and 08LO07-10, Sak Chai Quarry section, Pha Nok Khao Formation, Loei Province, northeastern Thailand, Early Permian.

***Bairdia galei* Croneis & Thurman *sensu* Shi & Chen, 1987**

Plate 3, Figures 6-8

1987 *Bairdia galei* Croneis & Thurman, 1939. Shi & Chen: 37, pl.1, figs.19-22

Materials: nine incomplete carapaces

Measurement: H=0.40-0.55 mm, L=0.77-0.99 mm, H/L=0.48-0.54

Discussion: Tapering AB and PB with straight DB are features of the species. *Bairdia galei* Croneis & Thurman *sensu* Shi & Chen, 1987 has been proposed to a new species *B. deweveri* Crasquin, 2010 from Latest Permian of Meishan section, South China (Crasquin *et al*., 2010: page 19, Plate 7, Figures 15-20). However, the studied specimens are quite different from *B. deweveri*. Due to its acute AB and PB and the straight DB of both valves, the specimens herein are belonged to *B.galei* Croneis & Thurman *sensu* Shi & Chen, 1987.

Occurrence: Meishan section, Zhejiang Province, Latest Permian (Shi and Chen, 1987); sample number 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Middle Permian; sample number 07LB05-C2, Ta Kli section, Tak Fa Formation, Nakhon Sawan province, central Thailand, Middle Permian.

Bairdia cf. _bassoni_ Crasquin, 2010

Plate 3, Figures 9, 12

Materials: four complete carapaces and one incomplete carapace

Measurement: H=0.588-0.896 mm, L=0.916-1.30 mm, H/L=0.61-0.68

Discussion: The specimens are similar to *B. bassoni* Crasquin, 2010 from the Latest Permian of Meishan section, South China (Crasquin *et al*., 2010) by arched DB, ends compressed laterally, and greatest height located at mid-length. The studied specimens are not well-preserved, and it is obvious that they have wider overlap on DB than that of *B. bassoni*. *B.* cf. *bassoni* is differentiated from *B. altiarcus* Chen, 1958 by shifting of hinge line in dorsal view.

Occurrence: Sample number 07LB05-C3 and 07LB05-D2**,** Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Bairdia altiarcus Chen, 1958

Plate 3, Figures 10-11, 13

1958 *Bairdia altiarcus* Chen (sp.nov.); Chen: p.223, pl.3, figs.21-23, pl.4, figs.11, 12

non 1985b *Cryptobairdia altiarca* (Chen); Kozur: p.231, tab.II, pl.3, fig.1

2002 *Cryptobairdia altiarcus* (Chen); Shi & Chen: p.69, pl.7, figs.1-12

2008 *Bairdia altiarcus* Chen, 1958; Crasquin-Soleau *et al*.: pl.2, figs.5-6

Materials: seven complete carapaces

Measurement: H=0.47-0.60 mm, L=0.74-0.91 mm, H/L=0.63-0.66

Occurrence: Kwanshan and Lungtan sections, Chihsia Limestone, Nanking Province, Early Permian (Chen, 1958); Matan and Pingding sections, Guangxi, South China, Late Permian (Shi and Chen 2002); Lercara Formation, Sicily, Italy, Middle Triassic (Crasquin, 2008a); sample number 07LB05-B1, 07LB05-D2 and 07LB05-D3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Bairdia deweveri* Crasquin, 2010**

Plate 3, Figures 14-15

1987 *Bairdia* cf. *trianguliformis* Chen. Shi & Chen: 37-38, pl.2, figs.1-8

2008b *Bairdia galei* Croneis & Thurman, 1939 *sensu* Shi & Chen, 1987. Crasquin *et al*,: pl.12, figs.11-12

2010 *Bairdia deweveri* Crasquin sp. nov. Crasquin *et al*.: 19, pl.7, figs.15-20

Materials: 11 complete carapaces

Measurement: H=0.56-0.80 mm, L=1.13-1.61 mm, H/L=0.50-0.55

Discussion: The studied specimens have slightly longer carapace than those found from Latest Permian of Meishan section of South China (Crasquin *et al*., 2010).

Occurrence: Sample number 07PB03-3, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Middle Permian; sample number 07PB05-2 and 07PB05-3, Ban Naen Sawan I section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian; sample number 07LB05-A2, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Bairdia hassi Sohn _sensu_ Chen & Shi, 1982

Plate 3, Figure 16

1982 *Bairdia hassi* Sohn. Chen & Shi: 121, pl.4, figs.3-5

Materials: one incomplete carapace

Measurement: H=0.69 mm, L=1.07 mm, H/L=0.64

Occurrence: Nantong section, Jiangsu Province, Late Permian (Chen and Shi, 1982); sample number 07PB08-2, Ban Naen Sawan II section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian.

Bairdia cf. _pierrevalentini_ Crasquin, 2010

Plate 3, Figures 17-18

Materials: two incomplete carapaces

Measurement: H=0.45-0.46 mm, L=0.74-0.77 mm, H/L=0.58-0.62

Discussion: The specimens resemble *Bairdia pierrevalentini* Crasquin, 2010 from Latest Permian of Meishan section, South China (Crasquin *et al*., 2010) in general outline, but H/L ratio is varied from 0.58-0.62.

Occurrence: Sample number 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian

Bairdia cf. permagna Geis, 1932

Plate 3, Figures 1-5

Materials: 20 complete carapaces

Measurement: H=0.23-0.57 mm, L=0.51-1.28 mm, H/L=0.43-0.47

Discussion: *Bairdia* cf. *permagna* is characterized by long carapace, short and slightly convex DB, slightly concave ADB and PDB, convex AVB and PVB, and carapace lateral flattened. This species is similar to *Bairdia permagna* Geis, 1932 from Late Mississipian of U.S.A. in general outline, but it can be differentiated by more convex DB and flat AVB and PVB.

Occurrence: Sample number 07PB03-1, 07PB03-3 and 07PB03-5, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

***Bairdia* sp.1**

Plate 3, Figures 19-20

Materials: two complete carapaces

Measurement: H=0.551-0.620 mm, L=1.04-1.13 mm, H/L=0.52-0.54

Discussion: *Bairdia* sp.1 is characterized by a long hinge, straight and almost horizontal DB on RV, and convex DB at LV. This species can be compared to *Bairdia luntanensis* Chen, 1958 from Early Permian of Chihsia Limestone, South China (Chen, 1958: page 6, Plate 4, Figure1-8) in general outline, but it can be differentiated by the longer hinge line which is nearly horizontal at RV.

Occurrence: Sample number 07PB03-3 Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

***Bairdia* sp.2**

Plate 4, Figures 1-2

Materials: two complete carapaces

Measurement: H=0.40 mm, L=0.68 mm, H/L=0.58

Discussion: *Bairdia* sp.2 is identified by smoothly arched dorsal outline, DB of both valves are convex and curved upward on both ends. This species can be compared to *B. hassi* Sohn, 1960 from Late Carboniferous-Permian of central U.S.A. (Sohn, 1960) but it lacks of ventral ridge as presented in *B. hassi*. However, *B.* sp.2 is different from *B. hassi* Sohn, 1960 Late Permian of Nantong section in South China (in Chen and Shi, 1982) from and described from Latest Permian of Meishan section in South China (Crasquin *et al*., 2010).

Occurrence: Sample number 07PB03-3 Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

***Bairdia* sp.3**

Plate 4, Figures 3, 6

Materials: 13 complete carapaces

Measurement: H=0.442-0.998 mm, L=0.773-1.65 mm, H/L= 0.57-0.61

Discussion: *Bairdia* sp.3 is characterized by straight and steeply inclined DB on RV, and convex DB at LV. *B.* sp.3 has some similarities with *B. hassi* Sohn, 1960 from Late Carboniferous-Permian of central U.S.A. (Sohn, 1960) and with *B. garrisonensis* Chen, 1958 from Early Permian of Chihsia Limestone, South China (Chen, 1958). However, *B.* sp.3 has the wider AB and the longer carapace compared to the latter species.

Occurrence: Sample number 07PB03-3, 07PB03-7, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand; sample number 07PB04-3 and 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand. All from Early Permian.

***Bairdia* sp.4**

Plate 4, Figures 4-5, 7-8

Materials: seven complete carapaces

Measurement: H=0.411-0.511 mm, L=0.680-0.790 mm, H/L=0.60-0.64

Discussion: *Bairdia* sp.4 has bluntly rounded and short AB, and long and taper PB. AB and PB are laterally flat. This species can be compared to *B. subleguminoides* Chen, 1987 from Latest Permian of Meishan section in South China (Shi and Chen, 1987). The difference is that *B.* sp.4 is more tumid than *B. subleguminoides* which has the longer anterior part and H/L=0.49-0.50.

Occurrence: Sample number 07PB05-2 and 07PB05-3, Ban Naen Sawan I section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Middle Permian, sample number 08LB01-6, Khao Som Phot section, Tak Fa Formation, Lopburi

Province, central Thailand, late Middle Permian, sample number 08LO02-9, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, northeast Thailand, Early Permian.

***Bairdia* sp.5**

Plate 4, Figures 10-13

Materials: five complete carapaces and three incomplete carapaces

Measurement: H=0.469-0.501 mm, L=0.855-0.901 mm, H/L=0.54-0.55

Discussion: *Bairdia* sp.5 has highly incised dorsum. AB and PB are taperred and laterally flattened. This species is closed to *B. subleguminoides* Chen, 1987 from Late Permian of Meishan section in South China (Shi and Chen, 1987) in lateral view, such characters as strongly incised dorsum and centrally inflation in dorsal view suggest the different species.

Occurrence: Sample number 07PB03-3 Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

***Baridia* cf. *piscariformis* Chen *sensu* Chitnarin *et al*., 2008**

Plate 4, Figures 14-16

2008 *Bairdia* cf. *piscariformis* Chen, 1958. Chitnarin *et al*: 351, fig.6(5)

Materials: ten complete carapaces

Measurement: H=0.438-0.479 mm, L=0.871-0.917 mm, H/L=0.48-0.53

Discussion: This species is characterized by horizontal DB and strong overlap of LV on RV at ADB. This species belongs to *B.* cf. *piscariformis* Chen *sensu* Chitnarin *et al.*, 2008 from Middle Permian of Tak Fa Formation in central Thailand. The additional materials confirm that this species is far different from *B. piscariformis* Chen 1958, and belongs to a new species.

Occurrence: Tak Fa Formation, Phetchabun province, central Thailand, Middle Permian (Chitnarin *et al.*, 2008); sample number 07PB03-3 Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand Early Permian; sample number 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

***Bairdia* sp.6**

Plate 4, Figure 9

Materials: one right valve and one incomplete carapace

Measurement: H=0.590 mm, L=0.961 mm, H/L=0.61

Discussion: This specimen has a flat-thin beak which protruded from venteromedian part of the carapace. This species is identified doubtfully to the genus *Bairdia* because it has a truncated posterior end, and the beak is unusual.

Occurrence: Sample 07PB08-2, Ban Naen Sawan II section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian.

***Bairdia* sp.7**

Plate 4, Figure 19

Materials: one complete carapace and one incomplete carapace

Measurement: H=0.479-0.749 mm, L=0.764-1.11 mm, H/L=0.62-0.67

Discussion: *Bairdia* sp.7 has broadly arched dorsal outline and largely rounded AB. PB is round with medium radious of curvature, maximum convexity is located below mid height. *B.* sp.7 is compared to *B. subsymmetrica* Shi *sensu* Crasquin-Soleau *et al*., 2004 from Early Triassic of Turkey and to *Cryptobairdia folgeri* (Kellett, 1934) from Late Pennsylvanian and Early Permian of Kansas, U.S.A. but it can be differentiated by the more acute PB which located at lower position, respectively.

Occurrence: Sample number 07PB03-1, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07PB05-6, Ban Naen Sawan I section, Tak Fa Formaion, Phetchabun Province, central Thailand, Middle Permian.

***Bairdia* sp.8**

Plate 4, Figures 17-18, 20-21

Materials: ten complete carapaces

Measurement: H=0.280-0.594 mm, L=0.532-1.150 mm, H/L=0.48-0.52

Discussion: *Bairdia* sp.8 has angular dorsal outline, and AB is angular and pointing upward. PB is tapering, the extreamily is located ventrally. *B.* sp.8 is similar to *B. iwaizakiensis* Ishizaki, 1967 from Early Permian of Tassobe Formation in Japan in lateral view, angular DB, pointing AB and small and long PB. It differs from *B. iwaizakiensis* by the greatest height located in front of mid length which causes the more angular DB. This species can also be compared to *B. wushunbaoi* Crasquin, 2010 from Latest Permian of Meishan section in South China (Crasquin *et al*., 2010) but it has the longer carapace.

Occurrence: Sample 08LO02-10, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, Sample number 07PB04-2 and 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

***Bairdia* sp.9**

Plate 4, Figure 22

Materials: one carapace

Measurement: H=0.540 mm, L=1.06 mm, H/L=0.50

Discussion: *Bairdia* sp.9 has broadly arched dorsal outline whose ADB and PDB are nearly symmetry. ADB is longer than DB. The greatest height is located behind mid length. For the present, *B.* sp.9 cannot be compared to any known species.

Occurrence: Sample number 07PB03-3, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

Bairdia sp.10

Plate 5, Figures 1-3

Materials: eight complete carapaces

Measurement: H=0.30-0.570 mm, L=0.645-1.12 mm, H/L=0.45-0.46

Discussion: *Bairdia* sp.10 can be characterized by straight DB which is horizontal to slightly incline to anterior, and maximum curvature of AB is located below mid height. AVB and PVB are ventrally flattened. *B.* sp.10 is compared to *B. naumarae* Yegorov, 1965 from Frasnian in Russia (Yegorov, 1965). However, it differs from the latter species in maximum of convexity of AB and PB of *B*. sp.10 are located below mid height and are in a lower position than in *B.naumarae*.

Occurrence: Sample number 07PB03-1, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07PB05-6, Ban Naen Sawan I section, Tak Fa Formaion, Phetchabun Province, central Thailand Middle Permian; sample number 07LB05-2 and 07LB05-A2, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Bairdia sp.11

Plate 5, Figures 4-5

Materials: two complete carapaces

Measurement: H=0.571-0.593 mm, L=1.50-1.53 mm, H/L=0.50-0.53

Discussion: *Bairdia* sp.11 is characterized by small AB than PB, and maximum curvature of both ends are located at mid height. This species is attributed to genus *Bairdia* due to its acute PB and short DB. The posterior part and PB are wider than the anterior ones. At present, the species cannot be compared with any known species.

Occurrence: Sample number 07PB03-7, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

***Bairdia* sp.12**

Plate 5, Figures 7-8, 10-11

Materials: 13 complete carapaces

Measurement: H=0.20-0.27 mm, L=0.60-0.69 mm, H/L=0.36-0.45

Discussion: *Bairdia* sp.12 is identified by long carapace with narrow posterior part. PB is curved upward, and PVB is very long. *B.* sp.12 can be compared to *B. finalyi* Mehes, 1911 (in Crasquin-Soleau *et al.*, 2006) which is reported from Early Triassic of northwestern Guanxi in South China. But this species has the longer posterior part and its AB is located at higher position.

Occurrence: Sample number 07LB05-3, 07LB05-4, 07LB05-B3, 07LB05-C1, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand; sample number 08LB01-1, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand. All from late Middle Permian.

Bairdia sp.13

Plate 5, Figures 6, 9

Materials: six complete carapaces

Measurement: H=0.261-0.492 mm, L=0.455-0.867 mm, H/L=0.56-0.57

Discussion: *Bairdia* sp.13 is characterized by straight DB at RV, convex DB at LV, a wide overlap of LV on RV at DB. AVB and PVB are ventrally flattened. *B.* sp.13 can be compared to *B. subcontracta* Chen, 1987 from Late Permian of Meishan section, in South China (Shi and Chen, 1987) but such characters as the flat AB and PB, a strong overlap at DB, and H/L ratio of *B*. sp.13 suggest the different species.

Occurrence: Sample number 07PB03-3, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

Bairdia sp.14

Plate 5, Figures 12-15

Materials: ten complete carapaces

Measurement: H=0.60-0.78 mm, L=0.95-1.17 mm, H/L=0.63

Discussion: *Bairdia* sp.14 is characterized by short and swelling carapace, highly arched DB, and flat AB and PB. *B.* sp.14 is closed to *B. menardensis* Harlton, 1929 from Pennsylvanian of Menard Country, Texsas, U.S.A (Harlton, 1929) in either general outline or H/L ratio. Although, they are different by straight DB at RV in *B*. sp.14 but convex DB at RV in *B. menardensis*.

Occurrence: Sample number 07LB05-A3, 07LB05-B1, 07LB05-D3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian; sample number 08LB01-6, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

***Bairdia* sp.15**

Plate 5, Figures 16-18

Materials: three complete carapaces

Measurement: H=0.38-0.465 mm, L=0.86-0.975 mm, H/L=0.44-0.47

Discussion: *Bairdia* sp.15 is of spindle-like shape with long and broadly arched dorsal outline. DB is convex at LV and straight at RV. Median part of carapace is wide, and VB is concave. *B.* sp.15 can be compared to *B*. cf. *piscariformis* Chen *sensu* Chitnarin *et al*., 2008, and can be differentiated by the convex dorsal outline, the straight and inclined DB at RV, and narrow overlap at ADB.

Occurrence: Sample number 07LB05-5, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand; sample number 07PB05-6, Ban Naen Sawan I section, Tak Fa Formation, Phetchabun Province, central Thailand. All from Middle Permian.

***Bairdia* sp.16**

Plate 5, Figures 19-21

Materials: three complete carapaces

Measurement: H=0.41-0.58 mm, L=1.02-1.38 mm, H/L=0.40-0.42

Discussion: *Bairdia* sp.16 is cgharacterized by long carapace, arched dorsal outline, long and straight VB, and tapering PB. The maximum curvature of PB is located just above VB level. *B.* sp.16 can be compared to *B.indefinita* Guseva, 1972 which has been reported from Early Permian of Russia (Guseva, 1972). However, the overlap at DB of *B*. sp.16 is wider than that of *B.indefinita*.

Occurrence: Sample number 07LB05-A2 and 07LB05-C3, Ta Khli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Bairdia* sp.17**

Plate 5, Figures 22-23

Materials: two complete carapaces

Measurement: H=0.21-0.43 mm, L=0.49-1.05 mm, H/L=0.41-0.43

Discussion: *Bairdia* sp.17 is identified by its tapering AB and PB which are curved upward, and are laterally flattened. Due to the general outline of *B.* sp.17, there is none character recognized from any known species.

Occurrence: Sample number 07LB05-2 and 07LB05-3,Ta Kli section, Tak Fa Fromation, Nakhon Sawan Province, central Thailand, Middle Permian; sample number 08LB01-6, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

Bairdia sp.18

Plate 6, Figures 1-3

Materials: six complete carapaces and five incomplete carapaces

Measurement: H=0.33-0.68 mm, L=0.81-1.66 mm, H/L=0.38-0.44

Discussion: *Bairdia* sp.18 can be characterized by flat and long carapace, AB and PB are acuminate and laterally flattened. Ventral ridge at RV is presented. *B.* sp.18 is similar with *B.* sp.16 but is different in such characters as the narrower AB, lower position of maximum curvature of PB, and overlap along dorsal margin.

Occurrence: Sample number 07LB05-5, 07LB05-6, 07LB05-B1, 07LB05-B2, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Bairdia sp.19

Plate 6, Figures 4-6

Materials: six complete carapaces

Measurement: H=0.509-0.516 mm, L=0.868-0.889 mm, H/L=0.58

Discussion: *Bairdia* sp.19 has short carapace with straight and almost vertical PDB. AB and PB have small radius of curvature and are laterally flattened. The maximum of curvature of AB is located at very high level but PB's is located at very low level. This species is compared to *Bairdia rigasensis* Crasquin-Soleau, 1998 from Permian of Greece (Hydra Island) (Crasquin-Soleau and Baud, 1998) but differs in shorter carapace and absence of straight ridges along ventral margins of both valves.

Occurrence: Sample number 08LO07-7, 08LO07-8, 08LO07-10, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, Early Permian; sample number 07LB05-A3, 07LB05-C3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Bairdia* sp.20**

Plate 6, Figures 7-8

Materials: two complete carapaces

Measurement: H=0.370-0.707 mm, L=0.711-1.44 mm, H/L=0.49-0.52

Discussion: *Bairdia* sp.20 can be characterized by angular AB and PB which the maximum of curvature of both extramities are located almost at the same level. In lateral appearance, *B.* sp.20 is similar to *Acravicula branisai* Pribyl, 1987 from Early Permian of Bolivia (Pribyl and Pek, 1987). *A. branisai* was the only species of the genus *Acravicula* discovered in Permian whereas other species were recovered from Lower Devonian of Austria, France, and Spain (Bandel and Becker, 1975 in Pribyl and Pek, 1987). The illustration of *A. branisai* is not clear enough for comparison with our specimens. So, these specimens are attributed to *Bairdia* sp.20.

Occurrence: Sample number 07LB05-B1 and 07LB05-C3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Bairdia sp.21

Plate 6, Figures 9-10

Materials: two complete carapaces and one incomplete carapace

Measurement: H=0.791 mm, L=1.38 mm, H/L=0.57

Discussion: *Bairdia* sp.21 has a thick and tumid carapace with a distinct overlap of LV on RV along dorsal margin. AB is broadly round with large radius of curvature. PB is round with small radius of curvature. At present, it cannot be compared to any known species.

Occurrence: Sample number 07LB05-B1 and 07LB05-5, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Bairdia sp.22

Plate 6, Figures 11-13, 16

Materials: seven complete carapaces and three incomplete carapaces

Measurement: H=0.40-0.48 mm, L=0.70-0.88 mm, H/L=0.50-0.56

Discussion: *Bairdia* sp.22 is a species of *Bairdia* whose anterior part of the carapace is narrow and elongate, posterior part is short. Dorsal outline is arched, ventral outline is broadly convex. AB is round with medium radius of curvature, maximum convexity is located above mid height. PB is short and round with small radius of curvature, maximum convexity is located just above VB level. Surface is smooth to punctuate. *B.* sp.22 cannot be compared to any known species.

Occurrence: Sample number 07LB05-2 and 07LB05-5, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Bairdia* sp.23**

Plate 6, Figures 14-15

Materials: two incomplete carpaces

Measurement: H=0.56-0.71 mm, L=1.09-1.31 mm, H/L=0.54-0.57

Discussion: *Bairdia* sp.23 is characterized by its angular dorsal outline, broadly convex AVB, maximum of curvature of AB located at high level, and with blunt PB. Two right valves of this species were recovered so that the overlap between LV and RV is still unknown. *B.* sp.23 cannot be compared to any known species.

Occurrence: Sample number 07LB05-B2 and 07LB05-C3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Bairdia* sp.24**

Plate 6, Figures 17, 20

Materials: two complete carapaces

Measurement: H=0.30-0.35 mm, L=0.53-0.66 mm, H/L=0.52-0.54

Discussion: *Bairdia* sp.24 is characterized by the posterior part of the carapace which is narrow and long, and PB is tapering. PVB and PB are ventrally flattened. *B.* sp.24 are compared to *B. subhassi* Belousova, 1965 from Late Permian of Russia (Belousova, 1965) but differs by the higher H/L ratio. *B.* sp.24 is differentiated from

B. sp.4 by the narrower overlap of LV on RV, the more elongate AB, and the higher H/L ratio.

Occurrence: Sample number 07LB05-5, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Bairdia sp.25

Plate 6, Figures 18-19

Materials: five complete carapaces

Measurement: H=0.38-0.41 mm, L=0.60-0.76 mm, H/L=0.58-0.59

Discussion: *Bairdia* sp.25 has a spindle-like carapace, AB and PB are round with small radius of curvature, maximum convexities are located almost at mid height. *B.* sp.25 can be compared to *B.* sp.15, but such characters as the higher H/L ratio and the more acuminate AB and PB suggest different species.

Occurrence: Sample number 07LB05-3 and 07LB05-4, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Bairdia sp.26

Plate 6, Figure 21

Materials: one complete carapace

Measurement: H=0.54 mm, L=0.60 mm, H/L=0.6

Discussion: *Bairdia* sp.26 is attributed to genus *Bairdia* due to its acute AB and short DB which suggest a typical Bairdian shape. *B.* sp.26 is characterized by its distinct and strong overlap of LV on RV along dorsal margin. AB is round, curved upward, and laterally flattened. In general, *B*. sp.26 can be compared to *Silenites limatus* Guan, 1978 from Early Permian of Hunan Province in South China (Guan *et al*., 1978), it cannot be compared to any known species of *Bairdia*.

Occurrence: Sample number 07PB05-2, Ban Naen Sawan I section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian.

***Bairdia* sp.27**

Plate 6, Figures 22-23

Materials: two complete carapaces and one incomplete carapace

Measurement: H=0.41-0.30 mm, L=0.76-0.80 mm, H/L=0.50-0.53

Discussion: *Bairdia* sp.27 has straight DB at RV, convex DB at LV, moderate overlap of LV on RV at DB, blunt PB. AB is laterally flattened. *B.* sp.27 can be compared to *B*. sp.26 but can be differentiated by the narrower overlap of LV on RV at dorsal margin.

Occurrence: Sample number 07LB04-12, 07LB04-13, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian.

***Bairdia* sp.28**

Plate 7, Figures 1-2

Materials: three complete carapaces

Measurement: H=0.43-0.47 mm, L=0.75-0.85 mm, H/L=0.55-0.57

Discussion: *Bairdia* sp.28 is characterized by arched dorsal outline which is concave at both ends. AB is round with medium radius of curvature, maximum convexity is located at three-fourth of height (above mid height). PB is acute with small radius of curvature, maximum convexity is located at one-fourth of height (below mid height). ADB and PDB are concave. *B.* sp.28 cannot be compared to any known species.

Occurrence: Sample number 07LB04-8 and 07LB04-12, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian.

Bairdia sp.29

Plate 7, Figures 3, 6

Materials: three complete carapaces

Measurement: H=0.25-0.60 mm, L=0.48-1.12 mm, H/L=0.50-0.54

Discussion: *Bairdia* sp.29 has subfusiform carapace, arched dorsal outline, and straight ADB, PDB, AVB. AB and PB are laterally flattened. AB is round with medium radius of curvature, maximum convexity is located above mid height. PB is round with medium radius of curvature, maximum convexity is located at one-fourth of height (below mid height). *B.* sp.29 can be compared to *B.* cf. *subcontracta* Chen, 1987 *sensu* Shi and Chen, 1987 from Latest Permian of Meishan section in South China (Shi and Chen, 1987: Plate 4, Figures 1-8), but is differred by absence of ventral ridge.

Occurrence: Sample number 07PB03-1 and 07PB03-3, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province; sample number 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, all from Early Permian.

Bairdia sp.30

Plate 7, Figures 4-5

Materials: three complete carapaces and two incomplete carapaces

Measurement: H=0.43-0.54 mm, L=0.71-0.88 mm, H/L=0.60-0.62

Discussion: *Bairdia* sp.30 is identified by subelliptical carapace, dorsal outline is arched, AB and PB are broadly rounded. LV strongly overlaps on RV at DB. *B.* sp.30 can be compared to *Cryptobairdia folgeri (*Kellett, 1934) from Late Pennsylvanian and Early Permian of Kansas, U.S.A (Kellet, 1934) but PB of *B*. sp.30 is more obtuse than that of *C. folgeri*. *B*. sp.30 can be compared to *Silenites subsymmetrica* Chen, 1987 from Latest Permian of Meishan section, South China (Shi and Chen, 1987) in lateral view. However the studied specimens are attributed to genus *Bairdia* by its H/L ratio.

Occurrence: Sample number 07LB04-13, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian; sample number 07LB05-2, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, Middle Permian.

Bairdia sp.31

Plate 7, Figures 7-8

Materials: two complete carapaces

Measurement: H=0.76-0.78 mm, L=1.18-1.28 mm, H/L=0.61-0.64

Discussion: *Bairdia* sp.31 is characterized by straight DB at RV, VB at RV is very concave, LV strongly overlaps on RV at DB and VB. *B.* sp.31 can be compared to *B. bossoni* Crasquin, 2010 from Latest Permian of Meishan section, South China (Crasquin *et al*., 2010) but can be differentiated by the wider area of overlap at DB and VB.

Occurrence: Sample number 07LB05-5, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, Middle Permian.

***Bairdia* sp.32**

Plate 7, Figures 9, 12, 15

Materials: ten complete carapaces

Measurement: H=0.38-0.39 mm, L=0.64-0.61 mm, H/L=0.60-0.64

Discussion: *Bairdia* sp.32 has slightly convex DB. ADB and PDB are straight and slightly curved upward at both ends. AB and PB are round with small radius of curvature, maximum convexities are located above and below mid height, respectively. AVB and PVB are ventrally flattened. *B.* sp.32 can be compared to *B. thikiaensis* Crasquin-Soleau, 1998 from Permian of Greece (Hydra Island) (Crasquin-Soleau and Baud, 1998) but can be differentiated by the steeper ADB, PDB and AVB.

Occurrence: Sample number 07LB09-1 and 07LB09-2, Khao Phu Chongkho section, Tak Fa Formation, Lopburi Province, late Early Permian.

Bairdia sp.33

Plate 7, Figures 10-11

Materials: three complete carapaces

Measurement: H=0.45-0.52 mm, L=0.63-0.73 mm, H/L=0.70-0.73

Discussion: Species of *Bairdia* with highly arched dorsal outline, overlap of LV on RV at DB and ADB is strong and distinct. *Bairdia* sp.33 cannot be compared to any known species.

Occurrence: Sample number 07LB05-2, 07LB05-B1 and 07LB05-C2, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Bairdia sp.34

Plate 7, Figures 13-14

Materials: four complete carapaces

Measurement: H=0.29-0.30 mm, L=0.59-0.60 mm, H/L=0.49-0.50

Discussion: *Bairdia* sp.34 has long carapace, broadly arched dorsal outline, and strong overlap of LV on RV at dorsal margin. *B.* sp.34 cannot be compared to any known species.

Occurrence: Sample number 07LB09-1 and 07LB09-2, Khao Phu Chongkho section, Tak Fa Formation, Lopburi Province, central Thailand, late Early Permian.

Bairdia sp.35

Plate 7, Figures 16-19

Materials: seven complete carapaces

Measurement: H=0.31-0.63 mm, L=0.59-1.07 mm, H/L=0.52-0.54

Discussion: *Bairdia* sp.35 has long and subfusiform carapace. AB is elongate and round with medium radius of curvature, maximum convexity is located at three-fourth of height (above mid height). PB is elongate and round with small radius of curvature, maximum convexity is located at below mid height. PVB is convex and laterally flattened. *B.* sp.35 cannot be compared to any species known.

Occurrence: Sample number 08LO02-11, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, Early Permian; sample number 08LO07-1, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, Early Permian; sample number 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, Early Permian; sample number 07LB05-D3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, Middle Permian.

Bairdia sp.36

Plate 7, Figures 20-21

Materials: two complete carapaces

Measurement: H=0.36-0.61 mm, L=0.51-0.87 mm, H/L=0.58-0.59

Discussion: *Bairdia* sp.36 has highly arched dorsal outline with long and straight VB. DB, ADB and PDB are straight. AB is round with medium radius of curvature, maximum convexity is located at mid height. Posterior part is short, PB is round with small radius of curvature, maximum convexity is located below mid height. Overlaps of LV on RV is distinct along dorsal margin. At present, *B*. sp.36 cannot be compared to any known species.

Occurrence: Sample number 08LO02-1 and 08LO02-9, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, Early Permian.

***Bairdia* sp.37**

Plate 7, Figures 22-23

Materials: two complete carapaces

Measurement: H=0.38-0.40 mm, L=0.84-0.78 mm, H/L=0.45-0.50

Discussion: *Bairdia* sp.37 has broadly arched dorsal outline which is concave at anterior and posterior ends. VB is broadly convex. AB is round with small radius of curvature, maximum convexity is located almost at DB level. PB is round with small radius of curvature, maximum convexity is located at mid height. AVB and PVB are long and convex. *B.* sp.37 is similar to *B*. sp.8 in broadly curved AB and PB, but they are differentiated by presence of arched dorsal outline in *B*. sp.37, of angular dorsal outline in *B*. sp.8.

Occurrence: Sample number 08LO02-10 and 08LO02-11, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, Early Permian.

Bairdia sp.38

Plate 8, Figures 1-2

Materials: one complete carapace and four incomplete carapaces

Measurement: H=0.46 mm, L=1.09 mm, H/L=0.42

Discussion: *Bairdia* sp.38 can be characterized by broadly arched dorsal outline which is concave at anterior and posterior ends. A strong overlap of LV on RV is at DB and VB is concave. *B*. sp.38 can be compared to *B*. sp.37 by having broadly curved AB and PB, but they can be differentiated by distinct overlap at DB and concave VB.

Occurrence: Sample number 08LO02-10 and 08LO02-11, Tham Nam Maholan section, Nam Maholan Formation, Loei Province; sample number 08LO07-1 and 08LO07-2, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province. All from Early Permian.

Bairdia sp.39

Plate 8, Figures 3, 6, 9

Materials: three incomplete carapaces

Measurement: H= 0.36 mm, L= 1.52 mm, H/L=0.48

Discussion: Bairdia sp.39 is a species of *Bairdia* with large size of carapace. AB and PB are tapering, are curved upward, and maximum curvature of bothe ends are located almost at DB level. Ventral ridge is presented on VB at RV. *B.* sp.39 cannot be compared to any known species.

Occurrence: Sample number 08LO02-2 and 08LO02-10, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, Early Permian.

***Bairdia* sp.40**

Plate 8, Figures 4-5

Materials: one complete carapace and two incomplete carapaces

Measurement: H=0.42-0.53 mm, L=0.70-0.87 mm, H/L=0.58-0.60

Discussion: *Bairdia* sp.40 is characterized by its highly arched dorsal outline, DB is straight at RV, convex at LV which causes a strong overlap at DB. Greatest height is located behind mid length. *B.* sp.40 cannot be compared to any known species.

Occurrence: Sample number 08LO07-1 and 08LO07-7, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, Early Permian.

***Bairdia* sp.41**

Plate 8, Figures 7-8

Materials: one complete carapaces and one incomplete carapace

Measurement: H=0.50 mm, L=0.95 mm, H/L=0.52

Discussion: *Bairdia* sp.41 has long and narrow anterior and posterior parts of carapace. AB and PB are rounded with small radius of curvature, and are ventrally flattened. *B.* sp.41 can be compared to *B*. sp.35 but differs by the narrower anterior and posterior parts. AB of *B*. sp.41 is located at lower position.

Occurrence: Sample number 08LO07-7 and 08LO07-8, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, Early Permian.

***Bairdia* sp.42**

Plate 8, Figures 10-11

Materials: two complete carapaces and two incomplete carapaces

Measurement: H=0.34-0.60 mm, L=0.72-1.17 mm, H/L=0.46-0.51

Discussion: *Bairdia* sp.42 has long carapace. PB is bluntly rounded, maximum of curvature is located at mid height. *B.* sp.42 is attributed to genus *Bairdia* not *Bairdiacypris* due to its narrow AB. It can be compared to *Cryptobairdia pelikani* Kozur, 1985) from Middle and Late Permian of Hungary (Kozur, 1958: Plate 13, Figures 2, 5) but can be differentiated by the longer carapace and the smaller AB.

Occurrence: Sample number 08LO02-11, Tham Nam Maholan section, Nam Maholan Formation, Loei Province; sample number 08LO07-7 and 08LO07-8, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, All from Early Permian.

***Bairdia* sp.43**

Plate 8, Figures 13-15

Materials: four complete carapaces

Measurement: H=0.39-0.63 mm, L=0.79-1.30 mm, H/L=0.47-0.49

Discussion: *Bairdia* sp.43 is characterized by its long carapace, long DB, and short VB. AVB and PVB are convex. Maximum of curvature of PB is located below mid height. *B.* sp.43 cannot be compared to any known species.

Occurrence: Sample number 08LO02-1, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, Early Permian; sample number 07LB09-1 and 07LB09-2, Khao Phu Chongkho section, Tak Fa Formation, Lopburi Province, late Early Permian.

***Bairdia* sp.44**

Plate 8, Figures 16-17

Materials: two complete carapaces

Measurement: H=0.32-0.36 mm, L=0.58-0.76 mm, H/L=0.56

Discussion: *Bairdia* sp.44 has long carapace, convex AVB, and concave PDB. The maximum of curvature of AB is located almost at DB level. *B.* sp.44 cannot be compared to any known species.

Occurrence: Sample number 08LO07-8, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, Early Permian; sample number 08PB01, Khao Tham Yai locality, Phetchabun Province, late Middle Permian.

***Bairdia* sp.45**

Plate 8, Figures 19-20

Materials: two complete carapaces

Measurement: H=0.32-0.36 mm, L=0.58-0.76 mm, H/L=0.31-0.36

Discussion: *Bairdia* sp.45 has long carapace with narrow anterior and posterior parts. DB is horizontal, ADB and PDB are long. AB is round with medium radius of curvature, maximum convexity is located at or above mid height. PB is round with small radius of curvature, maximum convexity is located below mid heigh. VB, AVB and PVB are ventrally flattened. *B.* sp.45 cannot be compared to any known species.

Occurrence: Sample number 07LB05-3 and 07LB05-6, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, Middle Permian.

***Bairdia* sp.46**

Plate 8, Figures 22-23

Materials: three complete carapaces

Measurement: H=0.35-0.37 mm, L=0.87-0.89 mm, H/L=0.40-0.42

Discussion: *Bairdia* sp.46 has long carapace, long and horizontal DB, and long VB. AVB and PVB are convex. Maximum of curvature of PB is located at mid height. *B.* sp.46 is attributed to genus *Bairdia* not *Bairdiacypris* due to its acute PB. At present it cannot be compared to any *Bairdia* known species.

Occurrence: Sample number 08LB01-1, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

Bairdia sp.47

Plate 8, Figure 12

Materials: one complete carapace

Measurement: H=0.72 mm, L=1.50 mm, H/L=0.48

Discussion: *Bairdia* sp.47 is identified by triangular dorsal outline and triangular area of overlap of LV on RV at DB. *B.* sp.48 can be compared to *Fabalicypris? alta* Chen, 1958 from Early Permian of Chihsia Limestone in South China (Chen, 1958: Plate 17, Figures 12-13) but *B*. sp.47 has the sharper AB and PB than the latter species.

Occurrence: Sample number 07LB04-13, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian.

Bairdia sp.48

Plate 8, Figure 18

Materials: one complete carapace

Measurement: H=0.29 mm, L=0.68 mm, H/L=0.42

Discussion: *Bairdia* sp.48 has angular dorsal outline, maximum of curvature of AB is located very high, and maximum of curvature of PB is located at VB level. This species is compared to *B.* sp.19 but differs in more elongate carapaces with tapering PB which is located at VB level. B. sp.48 is compared to *B. rigasensis* Crasquin-Soleau, 1998 from Permian of Greece (Hydra Island) (Crasquin-Soleau and Buad, 1998) but differs in absence of straight ridges along ventral margins of both valves.

Occurrence: Sample number 08LB01-1, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

***Bairdia* sp.49**

Plate 8, Figure 21

Materials: one complete carapace

Measurement: H=0.36 mm, L=0.78 mm, H/L=0.46

Discussion: *Bairdia* sp.50 is characterized by maximum of curvature of AB located above DB level, AVB is broadly convex, PB is tapered and maximum of curvature is located at mid height. *B.* sp.50 can be compared to *Acanthoscapha takacsae* Kozur, 1985 from Middle and Late Permian of Hungary (Kozur, 1985: Plate 16, Figure 5). However; without spines on AB and PB, the precised identification cannot be made.

Occurrence: Sample number 08LO07-10, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, northeast Thailand, Early Permian.

***Bairdia* sp.50**

Plate 8, Figure 24

Materials: one complete carapace

Measurement: H=0.44 mm, L=0.88 mm, H/L=0.50

Discussion: *Bairdia* sp.50 has broadly rounded AB which its maximum convexity is located almost at DB level. PB is acute, maximum convexity is located at mid height. *B.* sp.50 cannot be compared to any known species.

Occurrence: Sample number 07LB09-2, Khao Phu Chongkho section, Tak Fa Formation, Lopburi Province, central Thailand, late Early Permian.

***Bairdia* sp.51**

Plate 9, Figure 1

Materials: one complete carapace

Measurement: H= 0.27 mm, L= 0.43 mm, H/L=0.62

Discussion: Bairdia sp.51 has broadly rounded AB, maximum of curvature of AB is located at mid height. PB is round with small radius of curvature, maximum convexity is located just above VB level. Posterior part of carapace is short and narrow. *B.* sp.51 is attributed to the genus *Bairdia* due to its acute PB.

Occurrence: Sample number 07LB09-2, Khao Phu Chongkho section, Tak Fa Formation, Lopburi Province, central Thailand, late Early Permian.

***Bairdia* sp.52**

Plate 9, Figure 2

Materials: one complete carapace

Measurement: H=0.58 mm, L=0.95 mm, H/L=0.61

Discussion: *Bairdia* sp.52 has rounded AB, maximum of curvature of AB is located almost at DB level. AVB is long and straight. PB is round with small radius of curvature, maximum convexity is located below mid height. AB and PB are laterally flattened.

Occurrence: Sample number 07LB04-13, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian.

***Bairdia* sp.53**

Plate 9, Figure 3

Materials: one incomplete carapace

Measurement: H=0.62 mm, L=1.23 mm, H/L=0.50

Discussion: *Bairdia* sp.53 is characterized by its long and straight DB and distinct overlap of LV on RV at DB, ADB and PDB. Only one broken specimen is found.

Occurrence: Sample number 08LO02-1, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, northeast Thailand, Early Permian.

***Bairdia* sp.54**

Plate 9, Figure 4

Materials: one incomplete carapace

Measurement: H=0.70 mm, L>1.16 mm, H/L about 0.60

Discussion: *Bairdia* sp.54 is characterized by its round, narrow and laterally flat AB, the maximum curvature of AB is located at mid height. A strong overlap of LV on RV is at DB and ADB. Only one broken specimen is found.

Occurrence: Sample number 08LO07-7, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, northeast Thailand, Early Permian.

Bairdia sp.55

Plate 9, Figure 5

Materials: one incomplete carapace

Measurement: H=0.33 mm, L=0.54 mm, H/L=0.61

Discussion: Bairdia sp.55 is a species of *Bairdia* whose AB is broadly rounded and maximum of curvature of AB is located above mid height. PB is small , maximum of curvature is located just above VB level. Posterior part of carapace is short and narrow. *B.* sp.55 can be compared to *B*. sp.51 but can be differentiated by the larger AB which is slightly curved upward.

Occurrence: Sample number 07PB08-2, Phu Phra That section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Middle Permian.

Bairdia sp.56

Plate 9, Figures 6, 9

Materials: two complete carapaces

Measurement: H=0.58-0.66 mm, L=0.83-0.87 mm, H/L=0.67-0.79

Discussion: *Bairdia* sp.56 has high carapace and very broadly rounded AB. PDB is inclined at more than 60 degree to posterior. Specimens found in this study are well preserved but are covered by sediment. Many parts of the specimens' carapaces are sheltered so that the identification cannot be made precisely. *B.* sp.56 cannot be compared to any known species.

Occurrence: Sample number 07LB05-D2 and 07LB05-D3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Bairdia* sp.57**

Plate 9, Figure 7

Materials: one complete carapace

Measurement: H=0.36 mm, L=0.73 mm, H/L=0.49

Discussion: *Bairdia* sp.57 has long and subrhomboidal carapace whose AB and PB are closed to 90 degree. DB and VB are long and straight. ADB and AVB are long and straight, AB is round with medium radius of curvature, maximum convexity is located above mid height. PDB and PVB are short and straight, posterior part of carapace is short, maximum of curvature of PB is located below mid heigh. *B*. sp.57 cannot be compared to any known species.

Occurrence: Sample number 07LB05-C1, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Bairdia* sp.58**

Plate 9, Figure 8

Materials: one complete carapace

Measurement: H=0.24 mm, L=0.45 mm, H/L=0.54

Discussion: *Bairdia* sp.58 is a species of *Bairdia* with blunt PB. Dorsal outline is arched, DB is long and straight, PDB is inclined nearly vertical. The maximum curvature of AB is located below mid height, the maximum curvature of PB is located at VB level. *B.* sp.58 cannot be compared to any known species.

Occurrence: Sample number 07LB05-B3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Bairdia* sp.59**

Plate 9, Figures 10-11

Materials: two complete carapaces

Measurement: H=0.36-0.58 mm, L=0.57-0.95 mm, H/L=0.58-0.61

Discussion: *Bairdia* sp.59 is characterized by subelliptical carapace, dorsal and ventral outlines are broadly convex. AB and PB are round with large radius of curvature, the maximum convexities are located at mid height. AB is larger than PB. LV overlaps on RV at DB. *B.* sp.59 cannot be compared to any known species.

Occurrence: Sample number 08LO07-10 and 08LO07-11, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, northeast Thailand, Early Permian.

***Bairdia* sp.60**

Plate 9, Figures 12, 18

Materials: three incomplete carapaces

Measurement: H=0.20-0.27 mm, L=0.59-0.84 mm, H/L=0.33-0.35

Discussion: *Bairdia* sp.60 is characterized by its flat and long carapace, long and straight VB. LV overlaps on RV at DB. *B.* sp.60 cannot be compared to any known species.

Occurrence: Sample number 08LB01-1, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

Bairdia sp.61

Plate 9, Figures 13-15

Materials: 14 complete carapaces

Measurement: H=0.35-0.45 mm, L=0.62-0.74 mm, H/L=0.57-0.61

Discussion: *Bairdia* sp.61 has a kite-shape carapace. AB is round with medium radius of curvature, maximum curvature is located above mid height. PB is acute, maximum convexity is located above VB level. *B.* sp.61 cannot be compared to any known species.

Occurrence: Sample number 08LO02-11, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, Early Permian; sample number 07PB04-2 and 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, Early Permian; sample number 07LB05-A1, 07LB05-B2, 07LB05-D2, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, Middle Permian.

Bairdia sp.62

Plate 9, Figures 16-17

Materials: two complete carapaces

Measurement: H=0.26-0.45 mm, L=0.58-1.00 mm, H/L=0.45-0.46

Discussion: *Bairdia* sp.62 is characterized by convex dorsal outline, convex DB, and straight AVB. AB is round with medium radius of curvature, maximum convexity is located above mid height. PB is round with small radius of curvature, maximum convexity is located above VB level. *B.* sp.62 is attributed to genus *Bairdia* not *Acratia* because it lacks of "Acratian beak" which is the specific character of the latter genus. At present, *B*. sp.62 cannot be compared to any known species.

Occurrence: Sample number 07LB05-2 and 07LB05-3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Bairdia sp.63

Plate 9, Figures19-20

Materials: two complete carapaces

Measurement: H=0.44-0.68 mm, L=0.99-1.45 mm, H/L=0.44-0.47

Discussion: *Bairdia* sp.63 is identified by broadly arched dorsal outline which is concave at anterior end. Maximum of curvature of AB is located almost at DB level, AVB is long and very convex. Ventral outline is broadly convex. A distinct overlap of LVon RV is at DB. *B.* sp.63 can be compared to *B*. sp.37 and *B*. sp.38 in broadly arched dorsal outline, concave AB and PB, and broadly convex VB. But it can be differentiated from others by its broader AB than PB, straight DB on RV, and distinct overlap of LV on RV at DB.

Occurrence: Sample number 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

***Bairdia*? sp.**

Plate 11, Figure 15

Materials: one incomplete carapace

Measurement: H=0.40 mm, L=1.20 mm, H/L=0.33

Occurrence: Sample number 08LB01-6, Khao Som Phot section, Tak Fa Formation, Lopburi Province, late Middle Permian.

Genus *Lobobairdia* Kollomann, 1963

Type species: *Lobobairdia salinaria* Kollmann, 1963

***Lobobairdia ventriconcava* (Chen), 1958**

Plate 2, Figures 13-14

1958 *Bairdia ventriconcava* Chen (sp. nov.). Chen: 243, pl.3, figs.8-12

1986 *Lobobairdia ventriconcava* (Chen). Chen & Bao: 118, pl.2, figs.1-4

2002 *Lobobairdia ventriconcava* (Chen). Shi & Chen: 80, pl.14, figs.1-4, 12-14

Materials: eight complete carapaces and four incomplete carapaces

Measurement: H=0.48-0.61 mm, L=0.76-0.92 mm, H/L=0.63-0.66

Discussion: Horizontal ventral ridge on RV and dorsal ridge on LV are the specific characters suggest the species of *Lobobairdia ventriconcava* (Chen, 1958).

Occurrence: Kwanshan and Lungtan sections, Chihsia Limestone, Nanking Province, Early Permian (Chen, 1958); Well-Bao-1, Chihsia Limestone, Jiangsu Province, Early Permian (Chen and Bao, 1986); Matan and Pingding sections, Guangxi, South China, Late Permian (Shi and Chen, 2002); sample number 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07PB05-2, 07PB07-1 and 07PB07-3, Ban Naen Sawan I and II sections, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian; sample number 08PB02-13, Phu Prathat section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian

Genus *Cryptobairdia* Sohn, 1960

Type species: *Bairdia ventricosa* Roth & Skninner, 1930

***Cryptobairdia seminalis* (Knight) *sensu* Shi & Chen, 1982**

Plate 2, Figures 1-3

1982 *Cryptobairdia seminalis* (Knight). Shi & Chen: 126, pl.4, fig.4 only

Non 1982 *Cryptobairdia seminalis* (Knight), Shi and Chen: 126, pl.4, figs.1-3

Materials: eight complete carapaces and two incomplete carpaces

Measurement: H=0.31-0.59 mm, L=0.43-0.84 mm, H/L=0.60-0.73

Discussion: The genus *Cryptobairdia* can be recognized by bluntly rhombic shape in lateral view, obtusely rounded AB, and strongly arched DB. This species belongs to *C. seminalis*, Knight described by Shi & Chen (1982) from Latest Permian of Nantong section, Jiangsu Province in South China (Shi and Chen, 1982), but is not the species of Knight (1928) from Upper to Middle Pennsylvanian of U.S.A.

Occurrence: Nantong section, Jiangsu Province, Latest Permian (Chen and Shi, 1982); sample number 07PB03-5 and 07PB03-7, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

Genus *Petasobairdia* Chen, 1982

Type species: *Petasobairdia bicornuta* Chen, 1982.

***Petasobairdia subnantongensis* Chen, 1987**

Plate 2, Figures 4-6

1982 *Petasobairdia nantongensis* Chen gen. *et* sp. nov. Shi & Chen: 130, pl.6, figs.7-9

1987 *Petasobairdia subnantongensis* Chen sp. nov. Shi & Chen: 47, pl.8, figs.1-4, pl.19, figs.8-9

2002 *Petasobairdia subnantongensis* Chen. Shi & Chen: 75, pl.14, figs.12-14

2010 *Petasobairdia subnantongensis* Chen, 1987. Crasquin *et al.*: 33, pl.6, figs.6-8, figs. F-H13

Materials: 23 complete carapaces and six incomplete carapaces

Measurement: H=0.45-0.62 mm, L=0.81-0.96 mm, H/L=0.56-0.65

Discussion: Straight DB at RV, slightly convex DB at LV, wide and flat overlap of LV on RV at DB are specific characters of *Petasobairdia subnantongensis*. H/L ratio of the studied specimens is less than the types described by Chen from Latest Permian of Meishan section, South China, (Chen and Shi, 1982).

Occurrence: Nantong section, Jiangsu Province, Latest Permian (Chen and Shi, 1982); Meishan section, Zhejiang Province, Latest Permian (Shi and Chen, 1987); Matan and Pingding sections, Guangxi, South China, Late Permian (Shi and Chen, 2002); Meishan section, Zhejiang Province, South-East China, Latest Permian (Crasquin *et al*., 2010); sample number 07PB05-2 and 07PB05-3, Ban Naen Sawan I section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian; sample number 08PB03-3, Phu Pra that section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian; sample number 07LB05-5, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Petasobairdia levicornuta* Chen, 2002**

Plate 2, Figures 10-11

2002 *Petasobairdia levicornuta* Chen sp. nov. Shi & Chen: 75, pl.16, figs.1-7, pl.17, figs.1-6

Materials: three complete carapaces

Measurement: H=0.56-0.69 mm, L=1.18-1.29 mm, H/L=0.46-0.54

Discussion: The present of dorsal ridge on LV suggests the species *Petasobairdia levicornuta*; however, the studied specimens have the smaller backward-pointing spine and the longer carapace than that of the type species of Chen (2002) from Latest Permian of Guangxi in South China (Shi and Chen, 2002).

Occurrence: Matan and Pingding sections, Guangxi. South China, Latest Permian (Shi and Chen, 2002); sample number 07PB05-4, 07PB05-5 Ban Naen Sawan I section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian.

***Petasobairdia* cf. *levicornuta* Chen, 2002**

Plate 2, Figures 7-9

Materials: six complete carapaces

Measurement: H=0.51-0.69 mm, L=1.07-1.29 mm, H/L=0.48-0.50

Discussion: *Petasobairdia* cf. *levicornuta* Chen, 2002 have horizontal dorsal ridge on LV with small nodes at both ends of the ridge. DB is straight and nearly horizontal at LV, is convex at RV. *P.* cf. *levicornuta* is closed to *P. levicornuta* Chen from Latest Permian of Guangxi in South China(in Shi and Chen, 2002: 75, Plate 16, Figures 1-7 and Plate 17, Figures 1-6), but it differs by the less H/L ratio. The dorsal ridge at LV of *P.* cf. *levicornuta* is longer than that of *P. levicornuta* with presence of small nodes at both ends.

***Petasobairdia* sp.1**

Plate 9, Figure 21

Materials: two left valves

Discussion: Presence of two dorsal nodes is the character of the genus *Petasobairdia;* however, more information is needed for the precised identification.

Occurrence: Sample number 07PB08-3, Ban Naen Sawan II section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian.

***Petasobairdia* sp. 2**

Plate 9, Figure 22

Materials: one incomplete carapace

Occurrence: Sample number 08LB01-6, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

***Petasobairdia*? sp**.

Plate 9, Figure 23

Materials: one complete carapace

Occurrence: Sample number 08LO01-3, Khao Tham Yai, Pha Nok Khao Formation, Phetchabun Province, central Thailand, late Middle Permian.

Genus *Pustulobairdia* Sohn, 1960

Type species: *Bairdia*? *pruniseminata* Sohn, 1954

***Pustulobairdia*? sp.**

Plate 9, Figure 24

Materials: one complete carapace

Discussion: This specimen is attributed to the genus *Pustulobairdia* due to its roughness and ornamentation on carapace surface.

Occurrence: Sample number 07PB06-5, Ban Naen Sawan II section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian.

Genus *Bairdiacypris* Bradfield, 1935

Type species: *Bairdiacypris deloi* Bradfield, 1935.

***Bairdiacypris longirobusta* Chen, 1958**

Plate 10, Figure 6

1958 *Bairdiacypris longirobusta* Chen sp.nov. Chen: 255. pl.7, figs.1-3

1987 *Bairdiacypris longirobusta* Chen. Shi & Chen: pl.12, figs.21-22

1982 *Bairdiacypris longirobusta* Chen. Shi & Chen: 136, pl.10, figs.12-18

2002 *Bairdiacypris longirobusta* Chen. Shi & Chen: pl.21, figs.4-7

Materials: one complete carapace

Measurement: H=0.58 mm, L=1.36 mm, H/L=0.42

Occurrence: Kwanshan and Lungtan sections, Chihsia Limestone, Nanking Province, Early Permian (Chen, 1958); Nantong section, Jiangsu Province, Latest Permian (Chen and Shi, 1982); Meishan section, Zhejiang Province, Latest Permian (Shi and Chen, 1987); Matan and Pingding sections, Guangxi. South China, Latest Permian (Shi and Chen, 2002); Sample number 07LB05-5, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

***Bairdiacypris* sp.1**

Plate 10, Figures 4-5

Materials: three complete carapaces

Measurement: H=0.30-0.46 mm, L=0.78-1.17 mm, H/L=0.38-0.40

Discussion: *Bairdiacypris* sp.1 is characterized by small and rounded PB, maximum of curvature of PB is located below mid height. Overlap of LV on RV is narrow all around the carapace. *B.* sp.1 cannot be compared to any species known.

Occurrence: Sample number 07LB04-13, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, late Early Permian, sample number 07LB05-2 and 07LB05-B1, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Bairdiacypris sp.2

Plate 10, Figures 7-9

Materials: five complete carapaces and two incomplete carapaces

Measurement: H=0.23-0.37 mm, L=0.60-0.96 mm, H/L=0.38

Discussion: *Bairdiacypris* sp.2 is characterized by wide overlap of LV on RV at ADB and PDB. Posterior part of carapace is short and bluntly rounded. *B.* sp.2 cannot be compared to any known species.

Occurrence: Sample number 07LB05-3, 07LB05-B2 and 07LB05-C1, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian; sample number 08LB01-1, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

Bairdiacypris sp.3

Plate 10, Figures 10-11

Materials: six complete carapaces and one incomplete carapace

Measurement: H=0.35-0.41 mm, L=0.81-0.95 mm, H/L=0.41-0.43

Discussion: *Bairdiacypris* sp.3 is characterized by straight DB, concave VB. AB and PB are broadly rounded. Overlap of LV on RV is narrow. *B.* sp.3 can be compared to *B. longirobusta* Chen, 1958 from Early Permian of Chihsia Limestone in South China (Chen, 1958: Plate 7, Figure 13) but can be differentiated by narrow overlap all around the carapace.

Occurrence: Sample number 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

***Bairdiacypris* sp.4**

Plate 10, Figures 13-18

Materials: 11 complete carapaces and one incomplete carapace

Measurement: H=0.31-0.51 mm, L=0.51-1.10 mm, H/L=0.43-0.47

Discussion: *Bairdiacypris* sp.4 has straight DB, concave VB. ADB is straight, AB is round with large radius of curvature, maximum convexity is located at mid height. PDB is slightly convex, PB is round with medium radius of curvature, maximum convexity is located below mid height. LV moderately overlap RV all around the carapace. *B.* sp.4 has short carapace than common species of the genus. DB is straight and generally inclined to posterior at steep angle. *B.* sp.4 cannot be compared to any known species.

Occurrence: Sample number 08LO07-8, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, northeast Thailand, Early Permian; sample number 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

***Bairdiacypris* sp.5**

Plate 10, Figures 19-22

Materials: ten complete carapaces

Measurement: H=0.33-0.41 mm, L=0.65-0.85 mm, H/L=0.47-0.55

Discussion: *Bairdiacypris* sp.5 is characterized by broadly arched dorsal outline, convex DB at LV, straight DB at RV. A wide overlap of LV on RV is along dorsal margin. *B.* sp.5 has intermediate characters between *Bairdia* and *Bairdiacypris*, thus; it is attributed to *Bairdiacypris* by its broadly rounded AB and PB. *B*. sp.5 can be compared to *Fabalicypris elliptica* Chen, 1958 from Early Permian of Chihsia Limestone in South China (Chen, 1958: Plate 7, Figures 7-9) but can be differentiated by the wider AB and the wider overlap at DB.

Occurrence: Sample number 07LB04-13, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian; sample number 07LB05-3, 07LB05-B3 and 07LB05-C1, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian; sample number 08LB01-2 and 08LB01-3, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

***Bairdiacypris* sp.6**

Plate 10, Figures 23-24

Materials: four complete carapaces

Measurement: H=0.45-0.63 mm, L=1.00-1.33 mm, H/L=0.44-0.46

Discussion: *Bairdiacypris* sp.6 has triangular area of overlap at DB. AB and PB are round with large radius of curvature, maximum convexities are located at and below mid height, respectively. *B.* sp.6 can be compared to *B. triangularis* Shi, 2002 from

Latest Permian of Guangxi in South China (Shi and Chen, 2002), but it can be differentiated by the wider AB and PB.

Occurrence: Sample number 08LO07-8, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, northeast Thailand, Early Permian; sample number 07PB05-2, Ban Naen Sawan I section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian

***Bairdiacypris* sp.7**

Plate 10, Figure 12 and Plate 11, Figure 1

Materials: three complete carapaces

Measurement: H=0.31-0.41 mm, L=0.58-0.81 mm, H/L=0.50

Discussion: *Bairdiacypris* sp.7 is characterized by its subrectangular carapace, DB and VB are long, AB is round with large radius of curvature, PB is bluntly rounded. *B.* sp.7 can be compared to *Silenites sasakwaformis* Shi, 1987 from Latest Permian of Meishan section in South China (Shi and Chen, 1987: Plate 15, Figures 22-25) but it can be differentiated by the narrower AB, the longer DB, and the less H/L ratio.

Occurrence: Sample number 07PB03-1, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, Early Permian; sample number 07PB05-6, Ban Naen Sawan I section, Tak Fa Formation, Phetchabun Province, Middle Permian.

Bairdiacypris sp.8

Plate 11, Figures 2-3

Materials: seven complete carapaces

Measurement: H=0.30-0.66 mm, L=0.67-1.25 mm, H/L=0.46-0.48

Discussion: *Bairdiacypris* sp.8 has broadly arched dorsal outline, convex DB at LV, and slightly convex DB at RV. LV overlaps RV at DB. *B.* sp.8 has intermediate characters between *Bairdia* and *Bairdiacypris*, attribution to *Bairdiacypris* is due to presence of long DB. *B.* sp.8 can be compared to *B*. sp.5 in general appearance but it can be differentiated from the latter species by strong overlap of LV on RV only at DB, not along entire dorsal margin.

Occurrence: Sample number 07LB04-4 and 07LB04-13, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, late Early Permian; sample number 07LB05-2 and 07LB05-A3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Genus *Fabalicypris* Cooper, 1946

Type species: *Fabalicypris wileyensis* Cooper, 1946.

Fabalicypris sp.1

Plate 11, Figures 4-6, 9

Materials: seven complete carapaces

Measurement: H=0.26-0.37 mm, L=0.60-0.83 mm, H/ =0.43-0.44

Discussion: *Fabalicypris* sp.1 is characterized by subelliptical carapace with broadly arched dorsal outline. ABis round with large radius of curvature, maximum convexity is located above mid height. VB is concave, greatest height is located in front of mid length. A narrow overlap of LV on RV is around the carapace. *F.* sp.1 cannot be compared to any known species.

Occurrence: Sample number 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

***Fabalicypris* sp.2**

Plate 11, Figures 7-8

Materials: four complete carapaces

Measurement: H=0.43-0.44 mm, L=0.91-1.02 mm, H/L=0.43-0.46

Discussion: *Fabalicypris* sp.2 has elliptical carapace, convex DB at LV, straight DB at RV. Overlap of LV on RV is important at DB. AB and PB are round with medium radius of curvature, maximum convexities are located at mid height. Greatest height is located at or behind mid length. *F.* sp.2 cannot be compared to any known species.

Occurrence: Sample number 07LB05-A3, Ta Kli section, Tak Fa Formation, Nokhon Sawan Province, central Thailand, Middle Permian.

Fabalicypris sp. 3

Plate 11, Figures 10-12

Materials: eight complete carapaces

Measurement: H=0.22-0.40 mm, L=0.42-0.83 mm, H/L=0.45-0.51

Discussion: *Fabalicypris* sp.3 has a kidney-like carapace with convex DB and cancave VB at both valves. AB and PB are round with medium radius of curvature, maximum convexities are located at mid height. LV overlaps moderately on RV all around the carapace. *F.* sp.3 cannot be compared to any known species.

Occurrence: Sample number 08LO01-4, Khao Tham Yai locality, Pha Nok Khao Formation, Phetchabun Province, northeast Thailand, late Middle Permian.

Fabalicypris sp.4

Plate 11, Figure 13

Materials: one complete carapace and one incomplete carapace

Measurement: H=0.39 mm, L=0.84 mm, H/L=0.46

Discussion: *Fabalicypris* sp.4 is characterized by its small PB which is round with small radius of curvature and maximum convexity is located at one-fourth of height (below mid height). Dorsal outline is broadly arched, DB is long, anterior and posterior parts are short, and VB is concave. *F.* sp.4 cannot be compared to any known species.

Occurrence: Sample number 07LB04-17, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian.

Genus *Silenites* Coryell & Booth, 1933

Type species: *Silenites silenus* coryell & Booth, 1933

Silenites sp.1

Plate 14, Figure 10

Materials: two complete carapaces

Measurement: H=0.49-0.50 mm, L=0.80-0.83 mm, H/L=0.60-0.62

Discussion: *Silenites* sp.1 is icharacterized by subelliptical carapace, convex DB at LV, straight and inclined DB at RV. LV overlaps RV at DB. *S.* sp.1 cannot be compared to any known species.

Occurrence: Sample number 08LB01-3 and 08LB01-6, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

Silenites sp.2

Plate 14, Figures 11-14

Materials: 14 complete carapaces

Measurement: H=0.42-0.58 mm, L=0.60-0.90 mm, H/L=0.62-0.70

Discussion: *Silenites* sp.2 is characterized by subtriangular carapace, highly arched dorsal outline, convex DB at LV, straight and inclined DB at RV and a distinct overlap of LV on RV at DB. *S.* sp.2 cannot be compared to any species known.

Occurrence: Sample number 08LO02-5 and 08LO02-10, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, northeast Thailand, Early Permian; sample number 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07PB08-3, Ban Naen Sawan II section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian; sample number 07LB05-D2 and 07LB05-D3, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, Middle Permian; sample number 08LB01-3 and 08LB01-6, Khao Som Phot section, Tak Fa Formation, Lopburi Province, late Middle Permian.

***Silenites* sp.3**

Plate 14, Figure 15

Materials: one incomplete carapace

Measurement: H=0.55 mm, L=0.92 mm, H/L=0.60

Discussion: This specimen is attributed to genus *Silenites* by its subreniformis carapace, convex DB at LV, straight and horizontal DB at RV, and wide overlap of LV on RV at DB. *Silenites* sp.3 can be compared to *S. lenticularis* Knight *sensu* Shi & Chen, 2002 from Latest Permian of Matan and Pingding sections, Guangxi in South China (Shi and Chen, 2002), but it can be differentiated by a distinct and wide overlap at DB.

Occurrence: Sample number 07PB05-5, Ban Naen Sawan I section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian.

Genus *Liuzhinia* Zheng, 1976

Type species: *Liuzhinia subovata* Zheng, 1976

Liuzhinia sp.1

Plate 13, Figures 1-3

Materials: 29 complete carapaces

Measurement: H=0.26-0.44 mm, L=0.52-0.56 mm, H/L=0.47-0.58

Discussion: The genus *Luizhinia* can be recognized by subovate shape in lateral view, broad and round ends, AB larger than PB, convex DB, and AB flattened laterally. *Liuzhinia* sp.1 has subtrapazoildal carapace, ADB and PDB are long and straight. AB is laterally flattened and round with medium radius of curvature, maximum convexity is located below mid height. PB is acuminate and located at VB level. Ventral area is flat. In general, *L.* sp.1 is similar to specimens of genus *Acratia,* but it can be discriminated by lacking of concave AVB, also called acratian beak, an important feature of genus *Acratia*.

Occurrence: Sample number 07PB03-5, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07LB09-2, Khao Phu Chongkho section, Tak Fa Formation, Lopburi Province, central Thailand, late Early Permian; sample number 07LB05-B1 and 07LB05-B2, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian.

Liuzhinia sp.2

Plate 13, Figures 4-5

Materials: three complete carapaces

Measurement: H=0.29-0.30 mm, L=0.59-0.59 mm, H/L=0.50-0.51

Discussion: *Liuzhinia* sp.2 is characterized by subelliptical carapace, DB is straight, ADB and PDB are convex. AB is laterally flattened and round with large radius of curvature, maximum convexity is located at mid height. PB is round with medium radius of curvature, maximum convexity is located above VB level. Ventral area is flat. *L.* sp.2 can be compared to *L.* sp.1 in lateral outline, but it can be differentiated by round AB and PB with convex ADB and PDB.

Occurrence: Sample number 08LO02-5, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, northeast Thailand, Early Permian.

Liuzhinia sp.3

Plate 13, Figures 7-8

Materials: five complete carapaces

Measurement: H=0.16-0.85 mm, L=0.32-0.34 mm, H/L=0.51-0.52

Discussion: *Luizhinia* sp. 3 has subelliptical carapace, broadly arched dorsal outline, convex DB, ADB and PDB. AB is round with large radius of curvature, maximum convexity is located at mid height. PB is round but with the narrower radius of curvature than AB, maximum convexity is located below mid height. *L.* sp.3 can be differentiated from other species by slightly convex DB, round AB and PB with convex ADB and PDB.

Occurrence: Sample number 07LB09-2, Khao Phu Chongkho section, Tak Fa Formation, Lopburi Province, central Thailand, late Early Permian.

***Liuzhinia* sp.4**

Plate 13, Figures 6, 9

Materials: three complete carapaces

Measurement: H=0.20 mm, L=0.48-0.38 mm, H/L=0.41-0.52

Discussion: *Liuzhinia* sp.4 has subelliptical carapace, dorsal outline is broadly arched, ADB is convex, and PDB is slightly convex. Greatest height is located just in front of mid length. *L.* sp.4 cannot be compared to any known species.

Occurrence: Sample number 07LB04-13, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian.

Genus *Kempfina* Crasquin, 2010

Type species: *Bairdiacratia qinglaii* Crasquin 2008

***Kempfina qinglaii* (Crasquin, 2008)**

Plate 10, Figure 1

2008 *Bairdiacratia qinglaii* Crasquin n. gen. n. sp. Crasquin *et al*.: 246, pl.3, figs.13-16

Materials: one complete carapace

Measurement: H=0.58 mm, L=0.86 mm, H/L=0.67

Discussion: Generally, the lateral view of this specimen is similar to genus *Bairdia*. Presence of the concave AVB as acratian beak described by Crasquin *et al*. (2008) suggests the genus *Kempfina*.

Occurrence: Bulla section, northern Italy, late Changsigian, Late Permian (Crasquin *et al*., 2008a); sample number 07PB03-7, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

***Kempfina* sp.1**

Plate 10, Figure 2

Materials: three complete carapaces

Measurement: H=0.53-0.69 mm, L=0.78-1.15 mm, H/L=0.60

Discussion: *Kempfina* sp.1 is attributed to the genus *Kempfina* due to presence of the concave AVB (acratian beck). *K.* sp.1 is characterized by its long DB, wide overlap of LV on RV at DB, ADB, and PDB, but not at ADB and PDB points. At present, it cannot be compared to any known species.

Occurrence: Sample number 08LB01-2, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

Kempfina sp.2

Plate 10, Figure 3

Materials: one complete carapace and one incomplete carapace

Measurement: H=0.73 mm, L=1.20 mm, H/L=0.61

Discussion: *Kempfina* sp.2 has long DB, and wide overlap along dorsal outline, and PB is located at mid height. *K.* sp.2 is similar to *K.* sp.1 but it can be differentiated by a wide overlap all around the dorsal margin and maximum convexity of PB is located at mid height.

Occurrence: Sample number 08LO01-4, Khao Tham Yai locality, Pha Nok Khao Formation, Phetchabun Province, late Middle Permian.

Genus *Acratia* Delo, 1930

Type species: *Acratia typica* Delo, 1930

Acratia sp.1

Plate 13, Figures 10-24

Materials: 51 complete carapaces

Measurement: H=0.25-0.51 mm, L=0.66-1.18 mm, H/L=0.43-0.53

Discussion: The genus *Acratia* is recognized by presence of special feature called Acratian beak. *Acratia* sp.1 has acute AB and the acratian neck is distinct as a hook-like shape. Dorsal outline is broadly arched, DB is straight, ADB and PDB are convex. Greatest height is located just in front of mid length. *A.* sp.1 cannot be compared to any known species.

Occurrence: Sample number 08LO07-3, Sak Chai Quarry section, Pha Nok Khao Formation, Chiyaphum Province, northeast Thailand, Early Permian; sample number 07PB03-2, 07PB03-3 and 07PB03-5, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07LB05-6, Ta Kli section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, Middle Permian; sample number 08LB01-1, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

***Acratia* sp.2**

Plate 14, Figures 1-2

Materials: two complete carapaces

Measurement: H=0.39-0.40 mm, L=0.83-0.85 mm, H/L=0.46

Discussion: *Acratia* sp.2 is characterized by an unusual reverse overlap between RV and LV. At present, *A.* sp.2 cannot be compared to any known species.

Occurrence: Sample number 08LB01-1 and 08LB01-3, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

***Acratia* sp.3**

Plate 14, Figures 3-6

Materials: ten complete carapaces

Measurement: H=0.29-0.54 mm, L=0.56-1.01mm, H/L=0.49-0.53

Discussion: *Acratia* sp.3 is a species of *Acratia* with long acratian neck and a hook-like AB, maximum convexity of AB is located above mid height. *A.* sp.3 cannot be compared to any known species.

Occurrence: Sample number 08LO07-2, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, northeast Thailand, Early Permian; sample number 07PB03-3, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 08PB02-12, Phu Phra That section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian; sample number 07LB09-1, Khao Phu Chongkho section section, Tak Fa Formation, Lopburi Province, central Thailand, late Early Permian; sample number 08LB01-1, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

***Acratia* sp.4**

Plate 14, Figures 7-8

Materials: two complete carapaces

Measurement: H=0.28-0.33 mm, L=0.51-0.59 mm, H/L=0.53-0.56

Discussion: *Acratia* sp.4 can be characterized by subtrapazoildal carapace, and slightly convex DB, ADB, PDB. AB is laterally flattened, maximum of curvature of AB is located below mid height. PB is acuminate, maximum of curvature of PB is located at VB level. Ventral area is flat. At present, *A.* sp.4 cannot be compared to any known species.

Occurrence: Sample number 08LO07-1, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, northeast Thailand, Early Permian; sample number 08LB01-1, Khao Som Phot section, Tak Fa Fromation, Lopburi Province, central Thailand, late Middle Permian.

Genus *Baschkirina* Rozdestvenskaja, 1959

Type species: *Baschkirina memorabilis* Rozdestvenskaja, 1959

***Baschkirina* sp.1**

Plate 11, Figures 16-18

Materials: three complete carapaces

Measurement: H=0.17-0.22 mm, L=0.33-0.39 mm, H/L=0.50-0.60

Discussion: The genus *Baschkirina* is easily recognized by roughly triangular outline, narrowly curved AB and pointed PB. DB bends in the median part and at PB. Carapace is swollen with greatest thickness located in posterior part. *Baschkirina* sp.1 is characterized by its long carapace, long DB, round AB and PB. The maximum of curvature of PB is located at one-fourth of height (below mid height). At present, *B.* sp.1 cannot be compared to any known species.

Occurrence: Sample number 07LB09-2, Khao Phu Chongkho section, Tak Fa Formation, Lopburi Province, central Thailand, late Early Permian.

Baschkirina sp.2

Plate 11, Figures 19-21

Materials: five complete carapaces

Measurement: H=0.23-0.26 mm, L=0.45-0.49 mm, H/L=0.49-0.52

Discussion: *Baschkirina* sp.2 is characterized by subtriangular and thin carapace. AB is round with large radius of curvature, maximum convexity is located at mid height. PB is round with small radius of curvature, maximum convexity is located at VB level. Greatest height is located in front of mid length. *B.* sp.2 can be compared to *B. huzhouensis* Forel, 2010 from Latest Permian of Meishan section, South China (in Crasquin *et al*., 2010: Plate 4, Figures 5-8)) but it can be differentiated by large AB which maximum of curvature is located higher than that of *B. huzhouensis.*

Occurrence: Sample number 08LB01-1, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

Baschkirina sp.3

Plate 12, Figures 1-2, 4-5

Materials: 17 complete carapaces

Measurement: H=0.35-0.51 mm, L=0.55-0.73 mm, H/L=0.64-0.69

Discussion: *Baschkirina* sp.3 is characterized by subtriangular carapace and highly arched dorsal outline. AB is strongly flattened laterally and round with medium radius of curvature, maximum of curvature is located below mid height. Greatest height is located at or in front of nmid length. PB is acute and located at VB level. The flat area of AB of *B.* sp.3 is a specific character which cannot be compared to any known species.

Occurrence: Sample number 08LO02-2, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, northeast Thailand, Early Permian; sample number 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

***Baschkirina* sp.4**

Plate 12, Figures 7-15

Materials: 35 complete carapaces

Measurement: H=0.23-0.42 mm, L=0.32-0.64 mm, H/L=0.62-0.76

Discussion: *Baschkirina* sp.4 is identified by very broadly rounded AB, and PDB is inclined almost vertical. The specimens present important variations in H/L ratio. *B.* sp.4 is compared to *B*. sp.1 but differs by the steeper inclined PDB and the taller carapace.

Occurrence: Sample number 08LO02-1, 08LO02-2 and 08LO02-10, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, northeast Thailand, Early Permian; sample number 07LB04-8, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian; sample number 07PB03-3, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

Baschkirina sp.5

Plate 12, Figures 16-19

Materials: 12 complete carapaces

Measurement: H=0.24-0.61 mm, L=0.32-0.34 mm, H/L=0.73-0.75

Discussion: Specific character of *Baschkirina* sp.5 is subcircular carapace and convex ventral outline which cannot be compared to any known species.

Occurrence: Sample number 07LB09-1 and 07LB09-2, Khao Phu Chongkho section, Tak Fa Formation, Lopburi Province, central Thailand, late Early Permian.

Family PACHYDOMELLIDAE Berdan & Sohn, 1961

Genus *Microcheilinella* Geis, 1933

Type species: *Microcheilus distortus* Geis, 1932.

Microcheilinella venusta Chen, 1958

Plate 15, Figures 13-14

1958 *Microcheilinella venusta* Chen (sp.nov.). Chen: 230 and 253, pl.2, figs.12-17

1982 *Microcheilinella venusta* Chen. Chen & Shi: 142, pl.11, figs.7-10

1987 *Microcheilinella venusta* Chen. Shi & Chen: 61, pl.15, figs.20-21

2002 *Microcheilinella venusta* Chen. Shi & Chen: 94, pl.24, figs.1-8

2010 *Microcheilinella venusta* Chen, 1958. Crasquin *et al*: 50, pl.3, figs.9-10, figs.22I-J

Materials: four complete carapaces

Measurement: H=0.30-0.33 mm, L=0.40-0.49 mm, H/L=0.68-0.76

Discussion: The studied specimens are shorter than *Microcheilinella venusta* found from Early Permian of Chihsia Limestone in South China (Chen, 1958), and from Latest Permian of Meishan section, South China (Crasquin *et al*., 2010).

Occurrences: Kwanshan and Lungtan sections, South China, Early Permian (Chen, 1958); Nantong section, Jiangsu Province, Latest Permian (Chen and Shi, 1982); Meishan section, Changxing, Zhejiang, South China, Latest Permian (Shi and Chen, 1987); Matan and Pingding sections, Guangxi, South China, Late Permian (Shi and Chen, 2002); Meishan section, South China, Latest Permian (Crasquin *et al*., 2010); sample number 07LB05-5, 07LB05-B1, Ta Kli section, Tak Fa Formation, Nokhon Sawan Province, central Thailand, Middle Permian.

***Microcheilinella* sp.1**

Plate 15, Figures 15-16

Materials: four complete carapaces

Measurement: H=0.26 mm, L=0.49 mm, H/L=0.53.

Discussion: *Microcheilinella* sp.1 is characterized by its subelliptical carapace, slightly convex DB. AB is round with smaller radius of curvature, maximum convexity is located below mid height. PB is larger than AB. Greatest thickness is located at mid length.

Occurrences: Sample number 07LB05-B2, Ta Kli section, Tak Fa Formation, Nokhon Sawan Province, central Thailand, Middle Permian.

Microcheilinella sp.2

Plate 15, Figures 17-20

Materials: four complete carapaces

Measurement: H=0.23-0.25 mm, L=0.44-0.53 mm, H/L=0.46-0.51

Discussion: *Microcheilinella* sp.2 is characterized by subrectangular carapace, small PB, bluntly round AB, and narrow overlap of LV on RV all around the carapace. Greatest thickness is located in front of mid length. *M.* sp.2 can be compared to *M. rectodorsata* Forel, 2010 from Latest Permian of Meishan section, South China (Crasquin *et. al*., 2010: page 46, Plate 3, Figures 1-7) but can be differentiated by the less H/L ratio and the narrower overlap of LV on RV.

Occurrences: Sample number 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 08LO07-1, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, Early Permian.

Microcheilinella sp.3

Plate 15, Figure 21

Materials: one complete carapace

Measurement: H=0.23 mm, L=0.64 mm, H/L=0.36

Discussion: *Microcheilinella* sp.3 is very distinctive by its very long and thick carapace with small PB. *M.* sp.3 cannot be compared to any known species.

Occurrences: Sample number 07LB05-B2 Ta Kli section, Tak Fa Formation, Nokhon Sawan Province, central Thailand, Middle Permian.

***Microcheilinella* sp.4**

Plate 15, Figure 12

Materials: one complete carapace and five incomplete carapaces

Measurement: H=0.53 mm, L=0.86 mm, H/L=0.62.

Discussion: *Microcheilinella* sp.4 is characterized by large size of carapace, a reverse overlap of RV on LV at PB, and a wide overlap around the carapace. *M.* sp.4 cannot be compared to any known species.

Occurrences: Sample number 07PB08-3, Ban Naen Sawan II section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian.

***Microcheilinella* sp.5**

Plate 16, Figures 22-24

Materials: five complete carapaces

Measurement: H=0.29-0.31 mm, L=0.45-0.54 mm, H/L=0.64

Discussion: *Microcheilinella* sp.5 has convex DB, strong invagination at DB, and PB laterally flattened. *M.* sp.5 cannot be compared to any known species.

Occurrences: Sample number 07LB05-B1, 07LB05-D3, Ta Kli section, Tak Fa Formation, Nokhon Sawan Province, central Thailand, Middle Permian.

Microcheilinella sp.6

Plate 16, Figure 1

Materials: one incomplete carapace

Measurement: H=0.40 mm, L=0.56 mm, H/L=0.71

Discussion: *Microcheilinella* sp.6 is characterized by distinct groove around the carapace. *M.* sp.6 cannot be compared to any known species.

Occurrences: Sample number 08LB01-2, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

Microcheilinella sp.7

Plate 16, Figure 2

Materials: seven complete carapaces

Measurement: H=0.33 mm, L=0.57 mm, H/L=0.59

Discussion: *Microcheilinella* sp.7 is characterized by subelliptic RV, subrhombic LV showing wide overlap of LV on RV at DB, AB, VB, and PB. *M.* sp.7 cannot be compared to any known species.

Occurrences: Sample number 07LB05-D2, Ta Kli section, Tak Fa Formation, Nokhon Sawan Province, central Thailand, Middle Permian.

Microcheilinella sp.8

Plate 16, Figure 3

Materials: one incomplete carapace

Measurement: H/L is about 0.6

Discussion: *Microcheilinella* sp.8 is characterized by large and thick carapace. *M.* sp.8 cannot be compared to any known species.

Occurrences: Sample number 08KB03-4, Ban Phu Pru section, Sai Yok Limestone, Kanchanaburi, Middle Permian.

Microcheilinella sp.9

Plate 16, fig.res 4-6

Materials: eight complete carapaces and three incomplete carapaces

Measurement: H=0.28-0.29 mm, L=0.43-0.44 mm, H/L=0.63-0.68

Discussion: *Microcheilinella* sp.9 is characterized by its distinct and uncommon part of shell protrudes at DB of RV. AB is bluntly round, PB is laterally flattened and round with medium radius of curvature. Overlap of LV on RV is wide all around the carapace. *M.* sp.9 cannot be compared to any known species.

Occurrences: Sample number 07PB05-2, Ban Naen Sawan I section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian.

***Microcheilinella* sp.10**

Plate 16, Figure 7

Materials: two complete carapaces

Measurement: H=0.24 mm, L=0.56 mm, H/L=0.42

Discussion: *Microcheilinella* sp.10 has thick and elliptical carapace, and the maximum of curvature of PB is located below mid height. *M.* sp.10 cannot be compared to any known species.

Occurrences: Sample number 08PB02-13, Phu Phra That section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian.

Genus *Bogerscottia* Kozur, 1985

Type species: *Bogerscottia gerryi* Kozur, 1985

***Bogerscottia*? sp.**

Plate 12, Figure 3

Materials: one incomplete carapace

Measurement: H=0.46 mm, L=0.77 mm, H/L=0.60

Discussion: This specimen belongs to Bairdioidae by its long and acuminate AB, maximum of curvature of AB is located above mid height. PB is tapered, maximum of curvature is located above VB level. This specimen is questionably attributed to the genus *Bogerscottia* due to its possibly broken posterior spine on RV.

Occurrence: Sample number 08LO05-7, Silasriburi Quarry section, Pha Nok Khao Formation, Khon Kean Province, northeast Thailand, Early Permian.

Genus *Paramacrocypris* Kozur, 1985

Type species: *Paramacrocypris schallreuti* Kozur, 1985

***Paramacrocypris* sp.**

Plate 12, Figure 6

Materials: one complete carapace

Measurement: H=0.50 mm, L=1.40 mm, H/L=0.35

Discussion: Very elongate outline, poorly convex DB, round AB and pointed or round PB suggest the genus *Paramacrocypris*. The studied specimen has long and flat carapace, highly arched dorsal outline, fused DB and PDB, long ADB, and concave VB. This species differs from *P. schallreuteri* Kozur, 1985 from Middle and Late Permian of Hungary (Kozur, 1985) by the more angular dorsal outline, the narrower AB and PB, and absence of concave ADB.

Occurrence: Sample number 08LB01-2, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

Genus *Cytherellina* Jone & Holl, 1869

Type species: *Beyrichia siliqua* Jones, 1855

Cytherellina sp.

Plate 12, Figures 20-21

Materials: two complete carapaces

Measurement: H=0.22-0.23mm, L=0.42-0.45 mm, H/L=0.45-0.50

Discussion: The genus *Cytherellina* is recognized by elongate carapace with maximum height located in posterior half, round AB and PB, nearly straight VB, and smooth surface. *Cytherellina* sp. is characterized by suboval carapace, AB and PB are round and located below mid height. Posterior part of the carapace is wider than the anterior on. Greatest height is located behind mid length. It can be compared to *Cytherellina*? *glandella* Whitfield, 1882 from Lower Carboniferous limestone in USA, but differs by the smaller size, position of AB and PB, and the more inflated in dorsal view.

Occurrence: Sample number 07LB04-17, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan Province, central Thailand, late Early Permian.

Bairdioidea sp. A

Plate 11, Figure 14

Materials: one complete carapace

Measurement: H=0.268 mm, L=0.586 mm, H/L=0.49

Occurrence: Sample number 08LO02-1, Tham Nam Maholan section, Nam Maholan Formation, Loei Province, northeast Thailand, Early Permian.

Family GEROIIDAE Grundel, 1962

Genus *Pseudoscanthoscapha* Kozur, 1985

Type species: *Pseudoscanthoscapha beckeri* Kozur, 1985

***Pseudacanthoscapha striatula*? (Shi, 1982)**

Plate 14, Figure 9

1982 *Acratia? striatula* Shi sp.nov. Chen & Shi: 139, pl.11, figs.9-11

1985 *Pseudacanthoscapha beckeri* Kozur n. gen.n.sp. Kozur: 110, pl.18, fig.9

1987 *Acratia striatula* Shi. Shi & Chen: 49, pl.11, figs.13-18, pl.17, figs.1-4

2008 *Pseudacanthoscapha beckeri* Kozur, 1985. Mette: pl.2, fig.1

2010 *Pseudacanthoscapha striatula* (Shi, 1982). Crasquin *et al.*: 53, pl.5, fig.4, fig.20D

Materials: one incomplete carapace

Discussion: This specimen is attributed with doubt to *Pseudacanthoscapha striatula* due to the lateral striation which is more developped here. AB of the carapace is broken, thus; the precise identification cannot be designated.

Occurrence: Sample number 08LO07-2, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, northeast Thailand, Early Permian.

Family CYTHERIDEIDAE Sars, 1925

Genus *Basslerella* Kellett, 1935

Type species: *Basslerella crassa* Kellett, 1935

***Basslerella* sp.1**

Plate 14, Figures 16-22

Materials: 60 complete carapaces

Measurement: H=0.28-0.36 mm, L=0.36-0.48 mm, H/L=0.71-0.80

Discussion: The genus *Basslerella* is recognized by flat ventral border and greatest thickness located at posterior end. *Basslerella* sp.1 is characterized by its subround to subelliptic carapace, faint striation on carapace surface, and flat ventral area. The striation on carapace surface is very delicate (may be due to either preservation or corrosion) that it can be observed only in some specimens. This striation is different from reticulation on carapace surface of *B. reticulata* Shi, 1987 from Latest Permian of Meishan section in South China (Shi and Chen, 1987). The more elliptical form of this species is similar to *B. obesa* Kellett *sensu* Shi & Chen 2002 from Late Permian of Matan and Pingding sections in South China (Shi and Chen, 2002: Plate 23, Figures 26-35) but differs by its faint striation.

Occurrences: Sample number 08LO07-10, Sak Chai Quarry section, Pha Nok Khao Formation, Chaiyaphum Province, northeast Thailand, Early Permian; sample number 07PB03-1, 07PB03-5, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07PB04-2, 07PB04-5, 07PB04-7, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07PB05-5, Ban Naen Sawan I section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian; sample number 07LB04-8, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan province, central Thailand, late Early Permian; sample number 07LB05-5, Ta Kli section, Tak Fa Formation, Nakhon Sawan province, central Thailand, Middle Permian; sample number 07LB09-1, 07LB09-2, Khao Phu Chong Kho locality, Tak Fa Formation, Nakhon Sawan province, central Thailand, late Early Permian.

***Basslerella* sp.2**

Plate 14, Figures 23-25

Materials: 21 complete carapaces

Measurement: H=0.20-0.56 mm, L=0.30-0.83 mm, H/L=0.64-0.73

Discussion: *Basslerella* sp.2 is characterized by long and subelliptic carapace, smooth surface, and wide and very flat ventral area. *B.* sp.2 cannot be compared to any known species.

Occurrences: Sample number 08LO02-1, 08LO02-2, Tham Nam Maholan section, Nam Maholan Formation, Loei province, northeastern Thailand, Early Permian; sample number 07LB05-B1, 07LB05-B2, 07LB05-A2, 07LB05-5, Ta Kli section, Tak Fa Formation, Nakhon Sawan province, central Thailand, Middle Permian.

Order PLATYCOPIDA Sars, 1866

Suborder PLATYCOPINA Sars, 1866

Superfamily CAVELLINOIDEA Egorov, 1950

Family CAVELLINIDAE Egorov, 1950

Genus *Cavellina* Coryell, 1928

Type species: *Cavellina puchella* Coryell, 1928.

***Cavellina* sp.1**

Plate 15, Figures 1-4

Materials: 12 complete carapaces

Measurement: H=0.31-0.41 mm, L=0.49-0.68 mm, H/L=0.58-0.63

Discussion: *Cavellina* sp.1 has subelliptical carapace, boardly arched dorsal outline, long ADB, convex PDB, and convex ventral outline. AB and PB are round, AB is narrower than PB. The maximum curvature of AB is located above mid height. LV strongly overlaps on RV at DB and VB. The specimens are different in lateral view which is due to dimorphism and size. Heteromorphs have the longer carapace and the wider and more rounded PB compared to the tectomorphs. Tectomorphs are shorter, ADB inclined at steeper angle than that of heteromorphs.

Occurrences: Sample number 07PB03-1, 07PB03-3, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07LB05-A3, 07LB05-A2, Ta Kli section, Tak Fa Formation, Nakhon Sawan province, central Thailand, Middle Permian.

Genus *Sulcella* Coryell & Sample, 1932

Type species: *Sulcella sulcata* Coryell & Sample, 1932

***Sulcella suprapermiana* Kozur, 1985**

Plate 15, Figures 5-8

1985 *Sulcella suprapermiana* Kozur n. sp. Kozur: 22, pl.5, figs.3-4

1998 *Sulcella suprapermiana* Kozur, 1985. Crasquin-Soleau & Baud: pl.4, figs.1-3

1999 *Sulcella suprapermiana* Kozur, 1985. Crasquin-Soleau *et al*.: pl.4, fig.15

2008b *Sulcella suprapermiana* Kozur, 1985. Crasquin *et al*.: 255, pl.6, fig.1-2

Materials: six complete carapaces

Measurement: H=0.27-0.50 mm, L=0.48-0.89 mm, H/L=0.50-0.56

Discussion: The genus *Sulcella* is differentiated from genus *Cavellina* by presence of a median sulcus. *Sulcella suprapermiana* is recognized by elongate carapace with faint and long sulcus.

Occurrences: Bűkk Mountains of Hungary, Middle and Late Permian (Kozur, 1985); Hydra Island of Greece, Early to Late Permian (Crasquin-Soleau and Baud, 1998); Khuff Formation, Oman Sultanate, Middle Permian (Crasquin-Soleau *et al*., 1999); Bulla section, northern Italy, Late Permian (Crasquin *et al*., 2008b); sample number 07PB03-1, 07PB03-3, 07PB03-5, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07LB04-8, 07LB04-12, 07LB04-13, 07LB04-17, Phu Lam Yai section, Tak Fa Formation, Nakhon Sawan province, central Thailand, late Early Permian; sample number

07LB05-C3, Ta Kli section, Tak Fa Formation, Nakhon Sawan province, central Thailand, Middle Permian; sample number 08LB01-1, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

***Sulcella mesopermiana* Kozur, 1985**

Plate 15, Figures 9-11

1985 *Sulcella mesopermiana* Kozur n.sp. Kozur: 22, pl.5, figs.3-4, 6, 8

1998 *Sulcella mesopermiana* Kozur, 1985. Crasquin-Soleau & Baud:

Materials: 43 complete carapaces

Measurement: H=0.30-0.47 mm, L=0.51-0.64 mm, H/L=0.53-0.59

Discussion: *Sulcella mesopermiana* is recognized by tumid carapace and slightly concave DB and VB.

Occurrences: Mountains of Hungary, Middle and Late Permian (Kozur, 1985); Hydra Island of Greece, Early to Late Permian (Crasquin-Soleau and Baud, 1998); sample number 07PB03-1, 07PB03-3, Khao Kana section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian.

Order MYODOCOPIDA Sars, 1866

Suborder CLADOCOPINA Sars, 1866

Family POLYCOPIDAE Sars, 1866

Genus *Polycope* Sars, 1866

Type species: *Polycope orbicularis* Sars, 1866.

Polycope sp.1

Plate 17, Figures 1-4

Materials: seven complete carapaces

Measurement: H=0.28-0.45 mm, L=0.26-0.40 mm, H/L=1.07-1.6

Discussion: Small and subcircular carapace in lateral outline suggest the genus *Polycope*. *Polycope* sp.1 is characterized by high and suboval carapace with straight DB. *P.* sp.1 cannot be compared to any known species.

Occurrences: Sample number 08LO02-1, 08LO02-2, Tham Nam Maholan section, Nam Maholan Formation, Loei province, northeastern Thailand, Early Permian; sample 07PB04-2, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07LB05-B2, Ta Kli section, Tak Fa Formation, Nakhon Sawan province, central Thailand, Middle Permian; sample number 07LB08-1, Khao Som Phot section, Tak Fa Formation, Lopburi Province, central Thailand, late Middle Permian.

Polycope sp.2

Plate 17, Figures 5-7

Materials: three complete carapaces

Measurement: H=0.39-0.40 mm, L=0.39-0.40 mm, H/L=1.00

Discussion: *Polycope* sp.2 has subequal and subcircular carapace. DB is convex on both valves with possibly incised dorsum. *P.* sp.2 cannot be compared to any known species.

Occurrences: Sample number 08LO02-5, Tham Nam Maholan section, Nam Maholan Formation, Loei province, northeastern Thailand, Early Permian.

Polycope sp.3

Plate 17, Figures 8-13

Materials: six complete carapaces

Measurement: H=0.25-0.48 mm, L=0.27-0.54 mm, H/L=0.88-0.96

Discussion: *Polycope* sp.3 has subcircular carapace and straight DB. *P*. sp.3 differs from *P*. sp.1 by the less H/L ratio, from *P*. sp.2 by straight DB and absence of possibly incised dorsum.

Occurrences: Sample number 08LO02-6, 08LO02-10 Tham Nam Maholan section, Nam Maholan Formation, Loei province, northeastern Thailand, Early Permian; sample number 07PB04-2, 07PB04-5, Nong Phai section, Pha Nok Khao Formation, Phetchabun Province, central Thailand, Early Permian; sample number 07LB09-1, Khao Phu Chongkho locality, Tak Fa Formation, Nakhon Sawan province, central Thailand, late Early Permian.

Polycope? sp.

Plate 17, Figures 14-16

Materials: three incomplete carapaces

Discussion: *Polycope*? sp. has special ornamentation on carapace surface which is fine ridges and pits. *P.*? sp. is attributed to the *Polycope* by its subcircular carapace, however; few specimens are found, delicate and incomplete.

Occurrences: Sample number 07PB06-5, Ban Naen Sawan II section, Tak Fa Formation, Phetchabun Province, central Thailand, Middle Permian.

CHAPTER IV

OSTRACOD DISTRIBUTIONS AND INTERPRETATION OF PALEOECOLOGY

The ostracods are at 98% benthic inhabitants. By this way, they are closely interdependant of the variations of the bottom environment. They are major tool for reconstruction of paleoenvironments. One application of ostracods which is generally accepted to have an advantage over other microfossils is in interpretation of paleoecology; therefore, this chapter is aimed to demonstrate the distribution of ostracods from the studied sections and how to interprete the paleoecology by using the ostracods as tools. In the first part, distribution and ecology of ostracods are summarized. Then the paleoecological characteristic of the ostracods and reconstruction of oxygen level with reference to the ostracods are briefly explained. The distribution of ostracods in the studied sections with the interpretation of the paleoecology are presented in the last part of the chapter.

4.1 Ostracod distributions and ecology

According to the literatures (Moore, 1961; Pokorny, 1987), the living ostracods are benthic at 98% (few pelagic forms are recorded) or pelagic throughout their life cycle. The endemism is due to the lack of a planktonic larval stage for dispersal. Benthic ostracods live in freshwater, brackish, and marine habitats.

The freshwater ostracods commonly have smooth, thin, weakly calcified, light carapaces which enable them to swim several centimetres above the substrate. Some of them are adapted to live in humid soils and leaf litter. Many of them eat detritus or smaller organisms such as diatoms, protists, bacteria. Few species are scavenger or predator. The marine benthic ostracods whose carapaces are heavier tend to be either crawlers, burrowers or interstitial, eating detritus or predating on protists or worms. They prefer muddy sands and silts than non-oxygen black muds, evaporite, or well-sorted quartz sands and calcareous sands. The ostracod carapaces are usually reflected their habitats or environment. The size, shape and sculpture of benthic ostracods usually reflect the stability, grain size and pore size of substrate which they live. For example; dwellers on coarser substrates are commonly thick with coarse sculpture, infaunas or burrowers of sandy substrates tend to be small, smooth and robust, the burrower of silts and muds are smooth and elongated (Figure 4.1). The rare nektonic ostracods swimming not far from the bottom are smooth, thin-shelled and ovate to subcircular in lateral view, and have long and active antennules and antennae.

Ostracods are ubiquitous but most species or genera can live only in specific salinity range, from the freshwater to hypersaline condition. Three main salinity assemblages are distinguished which are freshwater (<0.5 ppt), brackish-water (0.5-30 ppt), and marine (30-40 ppt). Hypersaline condition is the salinity of higher than 40 ppt. Generally, the marine ostracod density is highest in normal salinity condition.

Depth affects ostracod distributions; indeed, the ecological factors such as water pressure, temperature, salinity and dissolved oxygen change with depth and are paralleled by changes in ostracod fauna and diversity. Benthic marine ostracod depth assemblages may be categorized as inner-shelf (interior platform), outer shelf (exterior platform) and bathyal-abyssal. The shelf assemblages live between 0 to 200meters depth where the highest diversities tend to occur. The densest populations are found in marginal areas. Bathyal and abyssal assemblages are known as the psychrospheric fauna which occur mostly at depth of 1000 to 1500 meters and at temperatures of 4-6 degree Celcius. These ostracods are both smooth and ornate which presence of long spines (for example, biofacies IV in Figure 4.1). Like other animals, the tropical assemblages tend to be more diverse than those in higher latitudes.

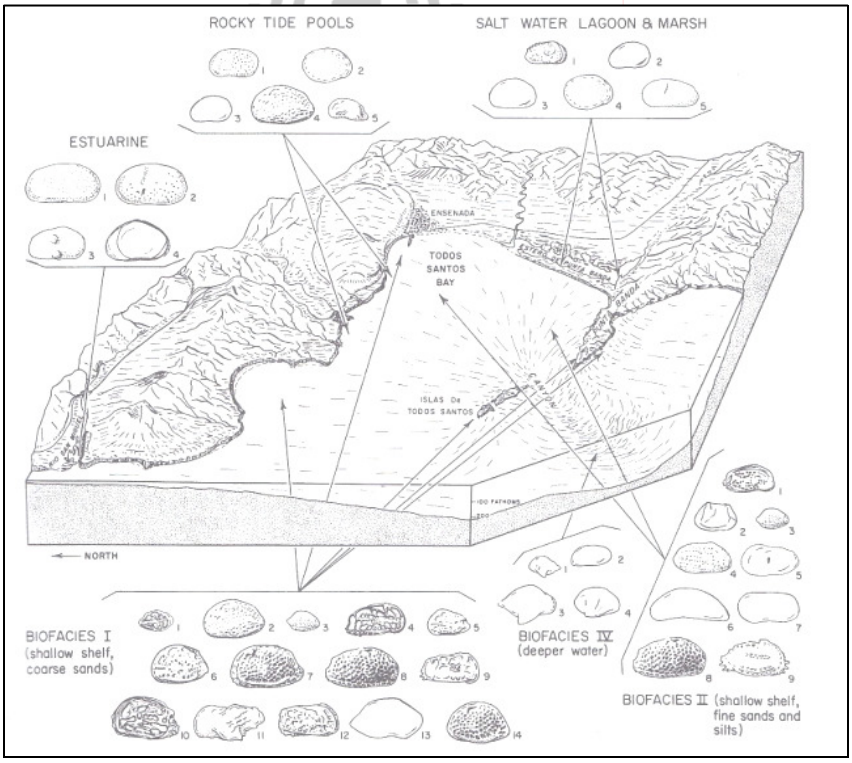

Figure 4.1 Distributions of various ostracod biofacies in the Todos Santos Bay Region, Mexico, and their major constituents (Moore, 1961). The carapace features such as size, shape, and ornamentation usually reflect their habitats.

4.2 Paleoecological characteristics of the ostracods

Paleoecological analysis using the ostracods is based on several methods; comparison of the mode of life of living species, functional morphology of the carapace characters, population structure of species, and structure of ostracod communities, analysis of accompanying fossil groups, and analysis of sediment (Pokorny, 1978). Among these methods, the paleoecological characteristic of ostracod families and/or superfamilies is relatively well known and has been applied to studies of the Late Paleozoic ostracods (Peterson and Kaesler, 1980; Crasquin, 1984; Costenzo and Keasler, 1987; and Melnyk and Maddocks, 1988a; 1988b). Thus, the interpretation of paleoecology of this thesis is based primarily on this method which uses percentage of species in different families and/or superfamilies.

According to the fore-mentioned authors, the main characteristics of the ostracod families and/or superfamilies recovered in this study can be summarized as follows (Figure 4.2).

Hollinoidea: should be crawler and swimmer on firm and stable substrates, in euryhaline shallow to very shallow water environment. Large species with developed adventral structure may indicate marginal environments such as interdistributary bay, prodelta, interdelta, and lagoon.

Kirkbyoidea: seems to be sublittoral inhabitant, under normal marine conditions, on firm mud calcareous substrates and to be crawler or swimmer.

Paraparchitidea: live in very shallow to shallow euryhaline environment, on firm terrigenous mud substrate, and are probably crawler. Some species can be tolerant to brackish and hypersaline environment, but are absent in the exterior platform.

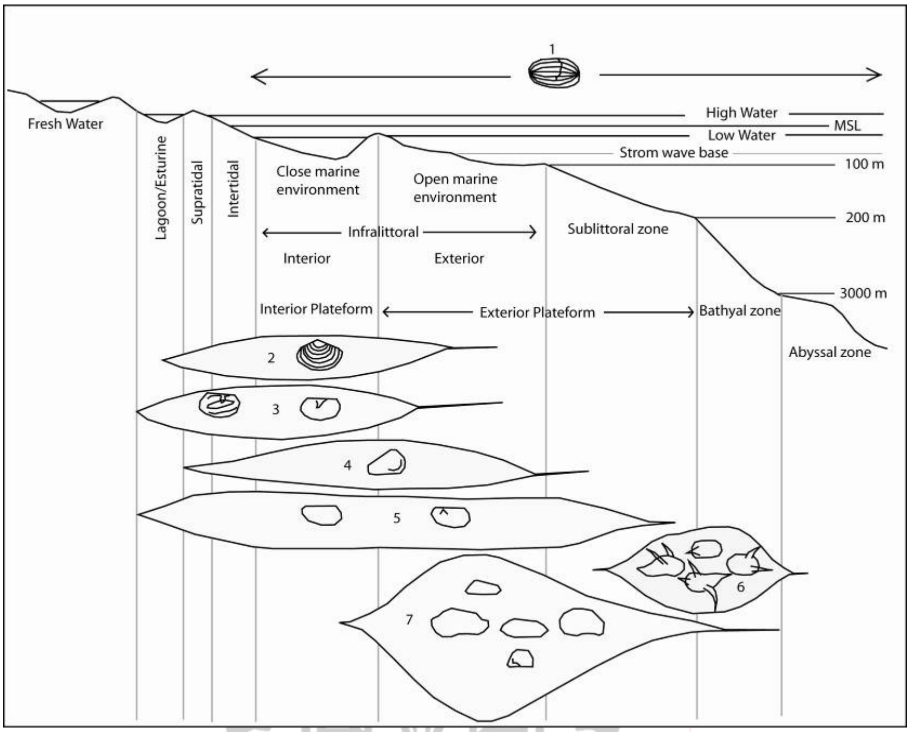

Figure 4.2 Schematic showing principle groups of Carboniferous ostracods distributed along the continental margin; 1: Entomozoidae; 2: Cryptophyllus; 3: Kloedenelloidea; 4: Cavellinidae; 5: Paraparchitidea; 6: Thuringian Ecozone; 7: Bairdioidea. (slightly modified after Crasquin, 1984)

Cavellinidae: live in very shallow to shallow euryhaline environment, on soft terrigenous mud substrates, and burrower mode of life.

Bairdioidea: live in shallow to deep, normal marine inhabitants, on firm calcareous mud substrates, in open carbonate environment, in warm water. Members of Bairdiocyprididae such as *Silenites* and *Baschkirina* prefer nearshore and muddy substrates.

Kloedenelloidea: are very shallow, euryhaline marine inhabitants, on stable, soft substrates and seem to be burrowers.

Youngielloidea: are inhabitants of shallow, normal marine environment.

Aparchitidae: species of *Cyathus* is probably an offshore inhabitant.

Cytherideidae: species of *Basslerella* is an exclusive offshore inhabitant, but some species of large size prefer nearshore environment.

Pachydomellidae: species of *Microcheilinella* is likely to be an offshore inhabitant.

Cladocopina: members of the group tend to live in nearshore, euryhaline environment.

In addition, most of the ostracod specimens recovered in this study are represented by closed carapaces which indicates limited transportation, soft substrates and relatively high rate of sedimentation (Oertil, 1971); (Figure 4.3). In other words, most of the specimens are closed carapaces found in matrix-supported limestone, and consisted of small- to large-size specimens.

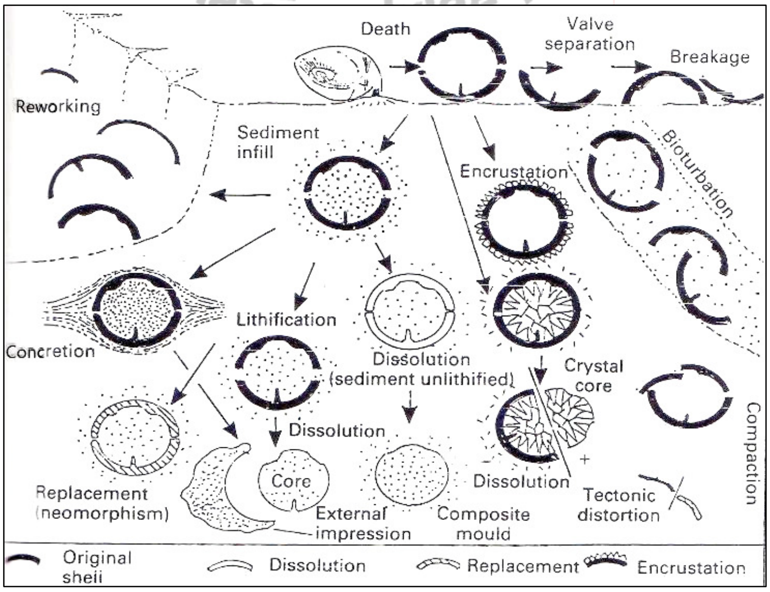

Figure 4.3 Mode of taphonomy of a bivalve shell including brachiopods and ostracods (Goldring, 1991)

4.3 Reconstruction of oxygen level in sea water with reference to ostracods

During the Palaeozoic, there were numerous different groups of filter-feeding ostracods which have been compared and demonstrated a relationship between the modes of feeding and respiration with certain post-Palaeozoic ostracods (Whatley, 1990; 1992). The filter-feeding ostracods, in contrast to deposit feeders, have a large number of branchial plates to enhance circulation over their ventral respiratory surface, and filter fine particles in suspension by using special tufts of setae and transport to the mouth. This form of feeding confer an advantage for filter-feeding ostracods during times or places where oxygen levels are low. Lethiers and Whatley (1994) demonstrated that this concept is true in the Palaeozoic; that is, they analyzed 43 localities between Emsian and Visean where the sedimentological and paleontological data are well known and where the changes in oxygen levels could not be explained by any other factors. They showed the increase of filter-feeder ostracods when oxygen level fall and vice-versa. According to them, the filter feeding ostracods of the Late Palaeozoic are the Palaeocopida including the Paraparchitidea, the Kloedenelloidea, and the Kirkbyoidea; the Platycopina including the Cavellinidae. The deposit feeders are of the Podocopida including the Bairdiocyprididae including genus *Microcheilinella* and the Bairdioidea. Lethiers and Whatley (1994) proposed a model to approximate the oxygen levels in sea water which allows the determination by using the percentage of filter feeding ostracods (Figure 4.4). This model is applied to this study in order to estimate the oxygen levels in some study sections.

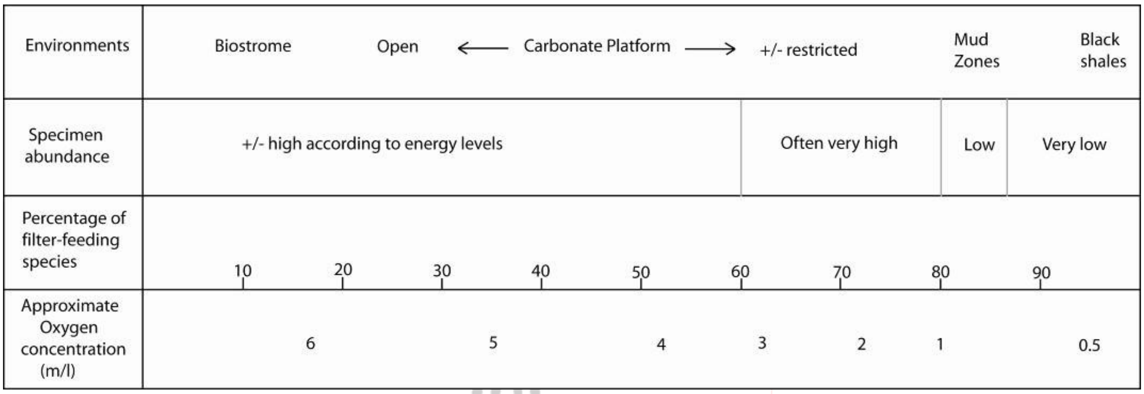

Figure 4.4 The model of oxygen level with reference to filter feeding ostracods (Lethiers and Whatley, 1994).

4.4 Distributions of the ostracods and interpretation of paleoecology of the studied sections

According to Chapters II and III, the Permian ostracods were recovered from limestone samples collected from the Loei, the Phetchabun, the Nakhon Sawan-Lopburi, and the Kanchanaburi areas as presented in Table 4.1. There are few ostracods recovered from the 08LO01 locality and the 08KB03 sections, that means there are not enough materials to interpret the paleoenvironment of these sections.

The main components of the Permian ostracod assemblages in this thesis are typical shallow marine species occupied the marginal marine environment to exterior platform (see Figure 4.2). They can be characterized by having thick and robust carapaces with smooth or reticulate surface and some ornamentation. Members of Bairdiodea (for example, *Bairdia*, *Acratia*, *Bairdiacypris*, *Bashkirina*) are abundant which may suggest the slightly offshore environment; however, their carapaces are usually thick, tumid to elongated, but not delicate or possessing spines like those features of the deep-water fauna (Crasquin, 1984; Yuan *et al.*, 2007).

Table 4.1 Repartition of the Permian ostracods recovered in this study

	Study area	LO				PB								LB				K
	Ostracod species	01	02	05	07	03	04	05	06	07	08	82	83	04	05	09	81	03
	Aparchitidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	*Cyathus* sp.1				+		+								+			
2	*Cyathus* sp.2						+								+			
	Kloedenelloidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	*Knoxiella* sp.1														+			
4	*Knoxiella* sp.2					+		+										
5	*Langdaia* sp.1													+			+	
6	*Geisina* sp.1					+									+			
7	*Eukloedenella* sp.1																	+
8	*Eukloedenella* sp.2														+			
9	*Eukloedenella?* sp.1															+	+	
10	*Eukloedenella?* sp.2														+			
11	*Eukloedenella?* sp.3														+			
12	*Sargentina* sp.1					+												
13	*Sargentina* sp.2					+												
14	*Geffenina* sp.1					+												
15	*Geffenina* sp.2													+				
16	*Kloedcytherella oertlii* Kozur, 1985												+	+	+			
17	Kloedenellidae indet.		+															
	Paraparchitidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	*Paraparchites* sp.1	+	+												+			
19	Paraparchitiidae sp.													+				
20	*Shemonaella* sp.1		+															
21	*Shemonaella* sp.2														+			
22	*Samarella* sp.1														+	+		
23	*Samarella* sp.2														+			
24	*Samarella* sp.3				+		+							+	+	+		
25	*Samarella* sp.4						+									+		
26	*Samarella* sp.5														+			
27	*Shishaella* sp.						+											
	Kirkbyoidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	*Kirkbya* sp.1					+												
29	*Kirkbya* sp.2					+												
30	*Kirkbya* sp.3				+													
31	*Knightina* sp.1														+			
32	*Knightina* sp.2															+		
33	*Knightina* sp.3		+															
34	*Knightina* sp.4						+				+				+			
35	*Reviya subsompongensis* Chitnarin, 2008											+	+					
36	*Shleesha* sp.											+						
37	*Polytylites* sp.				+										+			
38	*Kellettina* sp.					+	+											
39	*Permoyoungiella* sp.		+				+											

Explanation: LO= the Loei area, 01 = 08LO01, 02 = 08LO02, 05 = 08LO05, 07 = 08LO07; PB = the Phetchabun area, 03 = 07PB03, 04 = 07PB04, 05 = 07PB05, 06 = 07PB06, 07 = 07PB07, 08 = 07PB08, 82 = 08PB02, 83 = 08PB03; LB = the Nakhon Sawan-Lopburi area, 04 = 07LB04, 05 = 07LB05, 09 = 07LB09, 81 = 08LB01; K = the Kanchanaburi area, 03 = 08KB03; + = occur

Table 4.1 Repartition of the Permian ostracods recovered in this study (Continued)

	Study area	**LO**				**PB**								**LB**				**K**
	Ostracod species	01	02	05	07	03	04	05	06	07	08	82	83	04	05	09	81	03
	Hollinoidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	*Hollinella martensiformis* Crasquin, 2010					+	+							+	+	+		
41	*Hollinella herrickana* (Girty), 1909					+												
42	*Hollinella herrickana?* (Girty), 1909					+												
43	*Hollinella ?* sp.					+												
	Coelonellidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	*Microcoelonella* sp.1														+			
45	*Microcoelonella* sp.2														+			
46	*Microcoelonella?* sp.														+			
	Bairdioidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	*Bairdia mianyangensis* Chen, 1982					+												
48	*Bairdia guangxienesis* Guan, 1978								+	+	+							
49	*B. bassoni* Crasquin, 2010					+												
50	*B. girtyi* Sohn *sensu* Chen & Bao, 1986														+			
51	*B. lungtanensis* Chen, 1958		+			+									+			
52	*B. subleguminoides* Chen, 1987						+	+										
53	*B. urodeloformis* Chen, 1987														+			
54	*B.* cf. *urodeloformis* Chen, 1987				+										+			
55	*B.* cf. *calida* Chen, 1958					+		+										
56	*B. beedei* Ulrich & Bassler, 1906					+	+											
57	*B. zhongyingensis* Wang, 1978 *sensu* Chen&Bao, 1986														+			
58	*B. trianguliformis* Chen, 1958		+		+										+			
59	*B. galei* Croneis & Thurman *sensu* Shi & Chen, 1987						+								+			
60	*B.* cf. *bassoni* Crasquin, 2010														+			
61	*B. altiarcus* Chen, 1958														+			
62	*B. deweveri* Crasquin, 2010					+		+							+			
63	*B. hassi* Sohn *sensu* Chen & Shi, 1982										+							
64	*B.* cf. *pierrevalentini* Crasquin, 2010						+											
65	*B.* cf. *permagna* Geis, 1932					+												
66	*B.* cf. *piscariformis* Chen *sensu* Chitnarin *et al.,* 2008					+	+											
67	*Bairdia sp.* 1					+												
68	*Bairdia sp.* 2					+												
69	*Bairdia sp.* 3					+	+											
70	*Bairdia sp.* 4		+					+										
71	*Bairdia sp.* 5					+												
72	*Bairdia sp.* 6										+							
73	*Bairdia sp.* 7					+		+										
74	*Bairdia sp.* 8		+				+											
75	*Bairdia sp.* 9					+												
76	*Bairdia sp.* 10					+		+							+			

Explanation: LO= the Loei area, 01 = 08LO01, 02 = 08LO02, 05 = 08LO05, 07 = 08LO07; PB = the Phetchabun area, 03 = 07PB03, 04 = 07PB04, 05 = 07PB05, 06 = 07PB06, 07 = 07PB07, 08 = 07PB08, 82 = 08PB02, 83 = 08PB03; LB = the Nakhon Sawan-Lopburi area, 04 = 07LB04, 05 = 07LB05, 09 = 07LB09, 81 = 08LB01; K = the Kanchanaburi area, 03 = 08KB03; + = occur

Table 4.1 Repartition of the Permian ostracods recovered in this study (Continued)

	Study area	**LO**				**PB**								**LB**				**K**
	Ostracod species	01	02	05	07	03	04	05	06	07	08	82	83	04	05	09	81	03
	Bairdioidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77	*Bairdia sp.* 11					+												
78	*Bairdia sp.* 12														+		+	
79	*Bairdia sp.* 13					+												
80	*Bairdia sp.* 14														+		+	
81	*Bairdia sp.* 15														+			
82	*Bairdia sp.* 16														+			
83	*Bairdia sp.* 17														+		+	
84	*Bairdia sp.* 18														+			
85	*Bairdia sp.* 19				+										+			
86	*Bairdia sp.* 20														+			
87	*Bairdia sp.* 21														+			
88	*Bairdia sp.* 22														+			
89	*Bairdia sp.* 23														+			
90	*Bairdia sp.* 24														+			
91	*Bairdia sp.* 25														+			
92	*Bairdia sp.* 26							+										
93	*Bairdia sp.* 27													+				
94	*Bairdia sp.* 28													+				
95	*Bairdia sp.* 29					+								+				
96	*Bairdia sp.* 30													+	+			
97	*Bairdia sp.* 31															+		
98	*Bairdia sp.* 32															+		
99	*Bairdia sp.* 33														+			
100	*Bairdia sp.* 34															+		
101	*Bairdia sp.* 35		+		+		+											
102	*Bairdia sp.* 36		+															
103	*Bairdia sp.* 37		+															
104	*Bairdia sp.* 38		+		+													
105	*Bairdia sp.* 39		+															
106	*Bairdia sp.* 40				+													
107	*Bairdia sp.* 41				+													
108	*Bairdia sp.* 42		+		+													
109	*Bairdia sp.* 43		+													+		
110	*Bairdia sp.* 44	+			+													
111	*Bairdia sp.* 45													+				
112	*Bairdia sp.* 46																+	
113	*Bairdia sp.* 47													+				
114	*Bairdia sp.* 48																+	
115	*Bairdia sp.* 49				+													
116	*Bairdia sp.* 50															+		
117	*Bairdia sp.* 51															+		
118	*Bairdia sp.* 52													+				
119	*Bairdia sp.* 53		+															

Explanation: LO= the Loei area, 01 = 08LO01, 02 = 08LO02, 05 = 08LO05, 07 = 08LO07; PB = the Phetchabun area, 03 = 07PB03, 04 = 07PB04, 05 = 07PB05, 06 = 07PB06, 07 = 07PB07, 08 = 07PB08, 82 = 08PB02, 83 = 08PB03; LB = the Nakhon Sawan-Lopburi area, 04 = 07LB04, 05 = 07LB05, 09 = 07LB09, 81 = 08LB01; K = the Kanchanaburi area, 03 = 08KB03; + = occur

Table 4.1 Repartition of the Permian ostracods recovered in this study (Continued)

	Study area	LO				PB								LB				K
	Ostracod species	01	02	05	07	03	04	05	06	07	08	82	83	04	05	09	81	03
	Bairdioidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
120	*Bairdia sp.* 54				+													
121	*Bairdia sp.* 55											+						
122	*Bairdia sp.* 56														+			
123	*Bairdia sp.* 57														+			
124	*Bairdia sp.* 58														+			
125	*Bairdia sp.* 59				+													
126	*Bairdia sp.* 60																+	
127	*Bairdia sp.* 61		+				+							+				
128	*Bairdia sp.* 62														+			
129	*Bairdia sp.* 63						+											
130	*Bairdia? sp.*																+	
131	*Lobobairdia ventriconcava* Chen, 1958						+	+		+		+						
132	*Cryptobairdia seminalis* (Knight) *sensu* Shi & Chen, 1982					+	+											
133	*Petasobairdia subnantongensis* Chen,1987							+					+		+			
134	*P. levicornuta* Chen, 2002							+										
135	*P.* cf. *levicornuta* Chen, 2002														+			
136	*Petasobairdia* sp.1										+							
137	*Petasobairdia* sp. 2																+	
138	*P.*? sp.	+																
139	*Pustulobairdia*? sp.								+									
140	*Bairdiacypris longirobusta* Chen, 1958														+			
141	*Bairdiacypris* sp. 1													+	+			
142	*Bairdiacypris* sp. 2														+		+	
143	*Bairdiacypris* sp. 3						+											
144	*Bairdiacypris* sp. 4				+		+											
145	*Bairdiacypris* sp. 5													+	+		+	
146	*Bairdiacypris* sp. 6				+			+										
147	*Bairdiacypris* sp. 7					+		+										
148	*Bairdiacypris* sp. 8													+	+			
149	*Fabalicypris* sp. 1						+											
150	*Fabalicypris* sp. 2														+			
151	*Fabalicypris* sp. 3	+																
152	*Fabalicypris* sp. 4													+				
153	*Silenites* sp.1																+	
154	*Silenites* sp.2		+				+				+				+		+	
155	*Silenites* sp.3							+										
156	*Liuzhinia* sp.1					+									+	+		
157	*Liuzhinia* sp.2		+															
158	*Liuzhinia* sp.3															+		
159	*Liuzhinia* sp.4													+				
160	*Kempfina qinglaii* (Crasquin, 2008)					+												

Explanation: LO= the Loei area, 01 = 08LO01, 02 = 08LO02, 05 = 08LO05, 07 = 08LO07; PB = the Phetchabun area, 03 = 07PB03, 04 = 07PB04, 05 = 07PB05, 06 = 07PB06, 07 = 07PB07, 08 = 07PB08, 82 = 08PB02, 83 = 08PB03; LB = the Nakhon Sawan-Lopburi area, 04 = 07LB04, 05 = 07LB05, 09 = 07LB09, 81 = 08LB01; K = the Kanchanaburi area, 03 = 08KB03; + = occur

Table 4.1 Repartition of the Permian ostracods recovered in this study (Continued)

	Study area	**LO**				**PB**								**LB**				**K**
	Ostracod species	01	02	05	07	03	04	05	06	07	08	82	83	04	05	09	81	03
	Bairdioidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
161	*Kempfina* sp.1																+	
162	*Kempfina* sp.2	+																
163	*Acratia* sp.1				+	+									+		+	
164	*Acratia* sp.2																+	
165	*Acratia* sp.3				+	+	+					+				+	+	
166	*Acratia* sp.4				+												+	
167	*Baschkirina* sp. 1															+		
168	*Baschkirina* sp. 2																+	
169	*Baschkirina* sp. 3		+															
170	*Baschkirina* sp. 4		+			+	+								+			
171	*Baschkirina* sp. 5															+		
	Pachydomillidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
172	*Microcheilinella venusta* Chen, 1958															+		
173	*Microcheilinella* sp.1															+		
174	*Microcheilinella* sp.2				+		+											
175	*Microcheilinella* sp.3															+		
176	*Microcheilinella* sp.4										+							
177	*Microcheilinella* sp.5															+		
178	*Microcheilinella* sp.6																+	
179	*Microcheilinella* sp.7															+		
180	*Microcheilinella* sp.8																	+
181	*Microcheilinella* sp.9								+									
182	*Microcheilinella* sp.10												+					
183	*Bogerscottia?* sp.			+														
184	*Paramacrocypris* sp.																+	
185	*Cytherellina* sp.					+												
186	Bairdioidea sp.A		+															
	Geroiidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
187	*Pseudacanthoscapha striatula?* (Shi, 1982)				+													
	Cytherideidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
188	*Basslerella* sp.1				+	+	+	+						+	+	+		
189	*Basslerella* sp.2		+												+			
	Cavellinidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
190	*Cavellina* sp.1					+									+			
191	*Sulcella suprapermiana* Kozur, 1985					+								+	+		+	
192	*Sulcella mesopermiana* Kozur, 1985					+												
	Polycopidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
193	*Polycope* sp.1		+				+				+							
194	*Polycope* sp.2		+															
195	*Polycope* sp.3		+				+									+		
196	*Polycope ?* sp.								+									

Explanation: LO= the Loei area, 01 = 08LO01, 02 = 08LO02, 05 = 08LO05, 07 = 08LO07; PB = the Phetchabun area, 03 = 07PB03, 04 = 07PB04, 05 = 07PB05, 06 = 07PB06, 07 = 07PB07, 08 = 07PB08, 82 = 08PB02, 83 = 08PB03; LB = the Nakhon Sawan-Lopburi area, 04 = 07LB04, 05 = 07LB05, 09 = 07LB09, 81 = 08LB01; K = the Kanchanaburi area, 03 = 08KB03; + = occur

4.4.1 Ostracod distributions in Tham Nam Maholan section (08LO02); (Figure 4.5)

At the 08LO02 section, ten of twelve samples yielded ostracods, and the assemblage is dominated by Bairdioidea (58.1%). Other families are of Paraparchitidea, Kirkbyoidea, and Polycopidae (10.30% for each), Kloedenelloidea (7%), and Cytherideidae (4%). Presence of Kirkbyoidea, and Kloedenelloidea (17.30%) suggests very shallow water, euryhaline condition.

Consequently, the environment of the time of deposition is open marine environment, shallow water, subtidal, with wide range of salinity to normal salinity. The percentage of filter feeders (Paraparchitidea, Kloedenelloidea and Kirkbyoidea) is 27.6% suggesting oxygen concentration around 5.5 mL/L which is a normal marine condition.

4.4.2 Ostracod distributions in Sak Chai Quarry section (08LO07); (Figure 4.6)

The ostracod assemblage at the 08LO07 section is dominated by Bairdioidea (79.3%). Other families are of Paraparchitidea (6.87%), Kirkbyoidea (3.4%), Aparchitidae (3.4%), Pachydomellidae (3.4%), and Cytherideidae (3.4%). The environment of deposition is open marine, subtidal, offshore with normal salinity. The absence of the Kloedenelloidea and the presence of less the Paraparchitidea make differences between the 08LO02 section; that is, the deeper condition is preferred at the 08LO07 section. Besides, species of Cytherideidae (*Basslerella* sp.2) found in the latter section is of smaller size which may indicate the position farther seaward. The oxygen concentration is high (more than 6 mL/L) due to presence of few filter feeders.

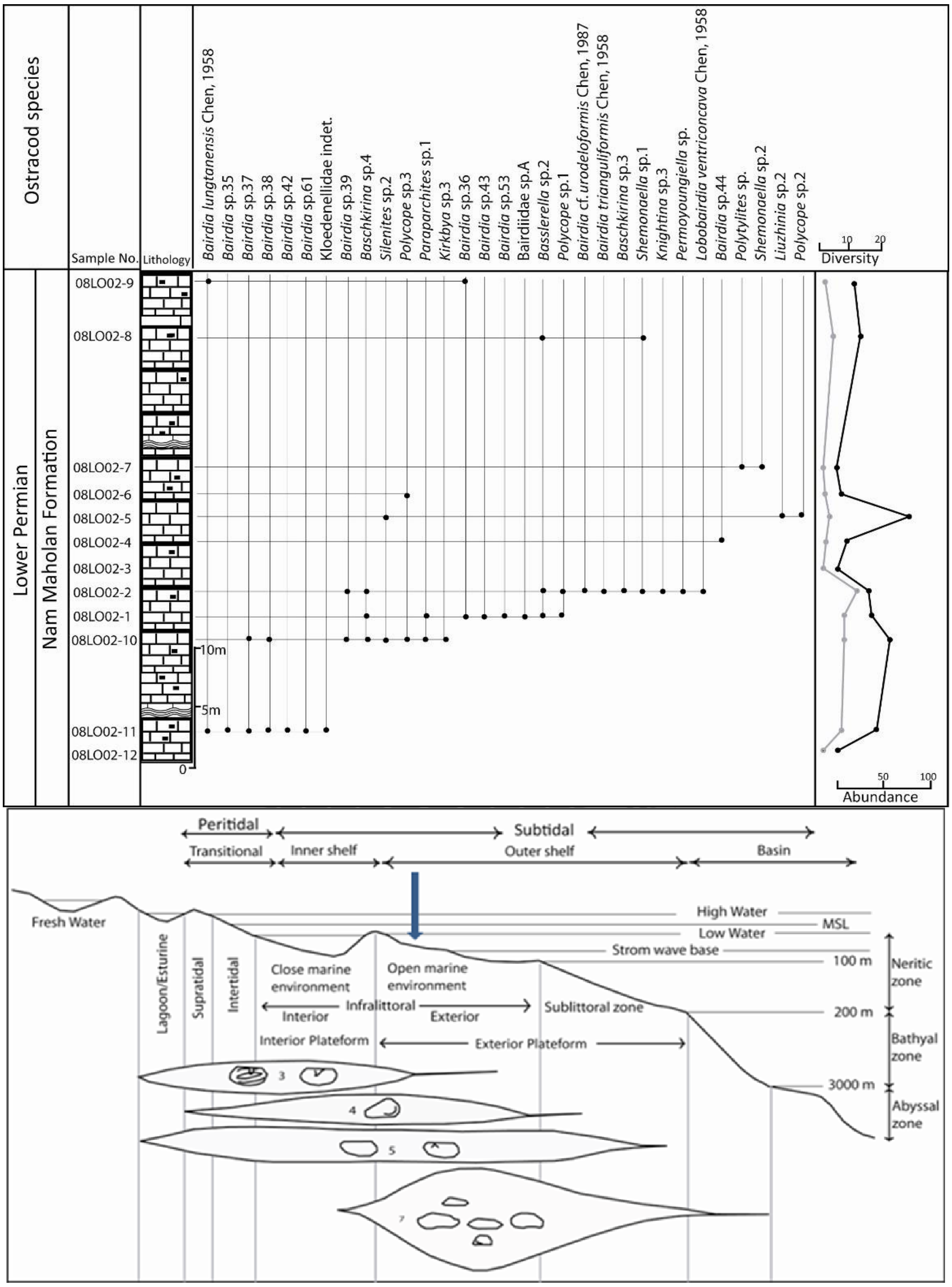

Figure 4.5 Distributions of ostracods in Tham Nam Maholan section (upper); schematic showing principle groups of Permian ostracods distributed along the continental margin (modified after Crasquin, 1984) and position of interpreted paleoenvironment (lower).

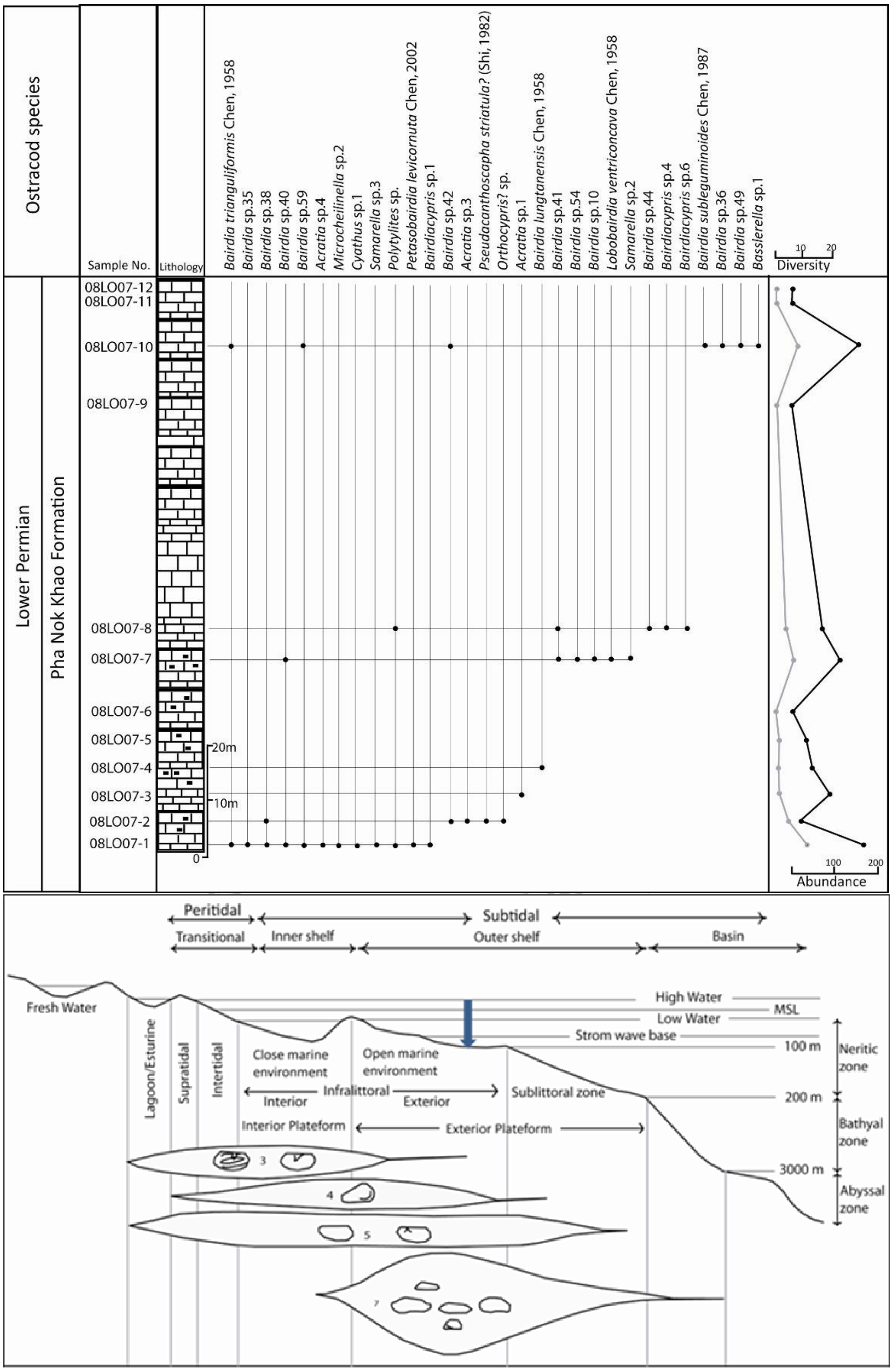

Figure 4.6 Distributions of ostracods in Sak Chai Quarry section (upper); schematic showing principle groups of Permian ostracods distributed along the continental margin (modified after Crasquin, 1984) and position of interpreted paleoenvironment (lower).

The ostracods are diversified and abundance in the lower part of the section where limestone is darker, intercalating with shale, and contained fossils such as brachiopods and bryozoa. In the upper part of the section where limestone is gray and clean, numbers of specimens are mostly of small *Basslerella* sp.2, in possibly deeper environment.

4.4.3 Ostracod distributions in Khao Kana section (07PB03); (Figure 4.7)

At the 07PB03 section, the ostracod assemblage is dominated by Bairdioidea (60%). Other families are of Kloedenellidae (14%), Kirkbyoidea (8.6%), Cavellinidae (8.6%), Hollinoidea (5.8%), and Cytherideidae (2.3%). Presence of Kloedenellidae and Kirkbyoidea (22.6%) suggest depositions in open marine environment, very shallow to shallow water, with high terrigenous deposits and with wide range of salinity to normal salinity. This is confirmed by presence of large species of Cavellinidae (genus *Sulcella*) which tend to live nearshore and Hollinoidea with developed adventral structure (*Hollinella herrickana* (Girty, 1909) which prefer soft muddy substrate in nearshore environment. However, the overall oxygen concentration is approximately 5.2 mL/L (filter feeder is 31.2%).

It is observed along the section that percentage of the Kloedenellidae, Kirkbyoidea, and Cavellinidae changes from 30%, 33%, 100%, 54%, and 20% in 07PB03-1, -3, -4, -5, and -7, respectively (Figure 4.8). This suggests the changes in local environment, possibly the small scale regression. The oxygen levels also change according to percent of filter feeders. However, 100% of filter feeders at level 07PB03-4 should not reflect the anoxic condition, but may be very low oxygen, high sediment inputs, or high tolerance of Kloedenellacean in such a hard condition.

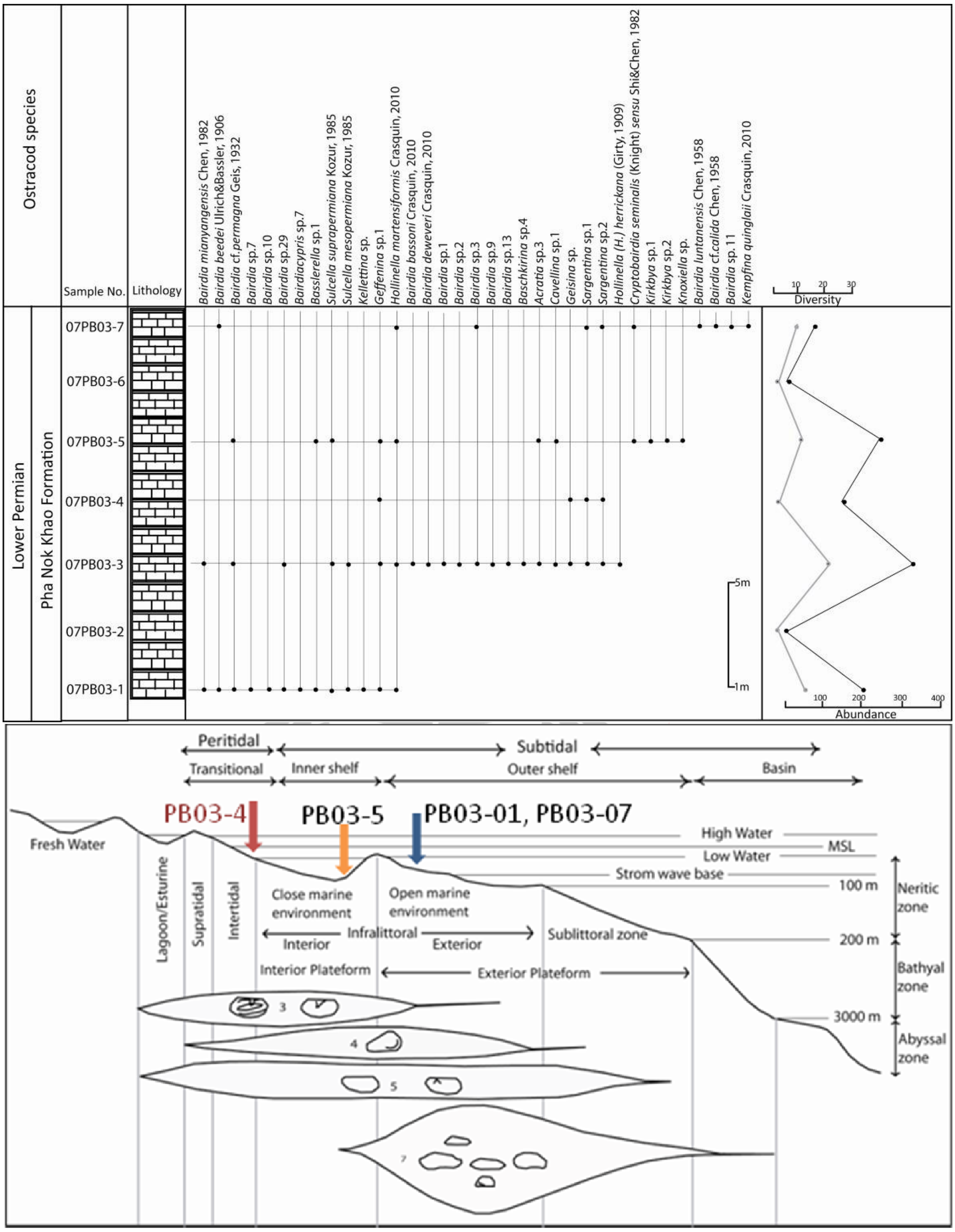

Figure 4.7 Distributions of ostracods in Khao Kana section (upper); schematic showing principle groups of Permian ostracods distributed along the continental margin (modified after Crasquin, 1984) and positions of interpreted paleoenvironments (lower).

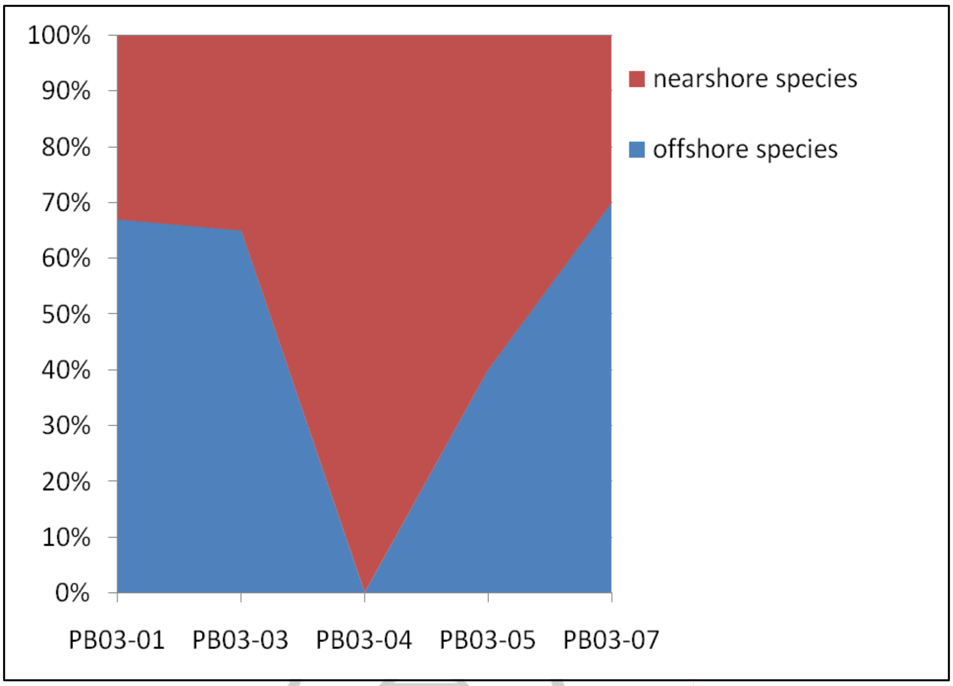

Figure 4.8 Diagram showing changes in composition of nearshore species (members of Kloedenelloidea, Kirkbyoidea, Hollinoidea, Youngielloidea, Cavellinoidea, Polycopidae) and offshore species (members of Bairdiidae, Pachydomellidae, Cytherideidae) along the 07PB03 section

It is obviously recognized at this section that The Kloedenellids are diversified and abundant in a very shallow marine environment. Carapaces of *Geffenina* sp.1, *Sargentina* sp.1, and *S.* sp.2 found in this section are robust and thick which could enable them to live as burrower. In contrast, the Bairdioidea are decreased in diversity and number of specimens in such shallow water with high terrigenous deposit. Carapaces of the *Bairdia* sp. found here are also thick and robust suggesting the nearshore habitants. It should be noted that diversity and abundance of ostracod fauna decrease if the environment reaches some constrains such as available oxygen or ability of feeding, only specific groups are able to live.

4.4.4 Ostracod distributions in Nong Phai section (07PB04); (Figure 4.9)

At this section, the ostracod assemblage is mainly composed of Bairdioidea (67.64%). Other families are of Paraparchitidea (8.82%), Polycopidae (5.8%), Kirkbyoidea (2.9%), Cavellinidae (2.9%), Hollinoidea (2.9%), Cytherideidae (2.9%), Pachydomellidae (2.9%), and Youngielloidea (2.9%). Accordingly, the environment is likely to be open marine environment, subtidal with normal salinity. Oxygen concentration of the overall section is higher than 6 mL/L.

Ostracods are found abundantly at the lower part of the section where limestones are of thin-bedded, dark gray, intercalated with shales. They are less in abundant in the upper part where limestones are of medium-bedded, gray, and showing wavy bedding. This may suggest that the fauna prefers the stable substrates below wave influence.

4.4.5 Ostracod distributions in Ban Nean Sawan I section (07PB05); (Figure 4.10)

At the 07PB05 section, the ostracod assemblage is mainly composed of Bairdioidea (86.95%). Other families are of Kloedenelloidea, Cytherideidae, and Pachydomellidae (4.43% for each). The environment of deposition is open marine, subtidal, slightly deep water with normal salinity and high oxygen concentration.

The presence of diversified Bairdioidea may suggest a more distral part in the open marine environment; nevertheless, the specimens have mostly thick and tumid carapaces represented high saturation of calcium carbonate, and have possibly burrower mode of life.

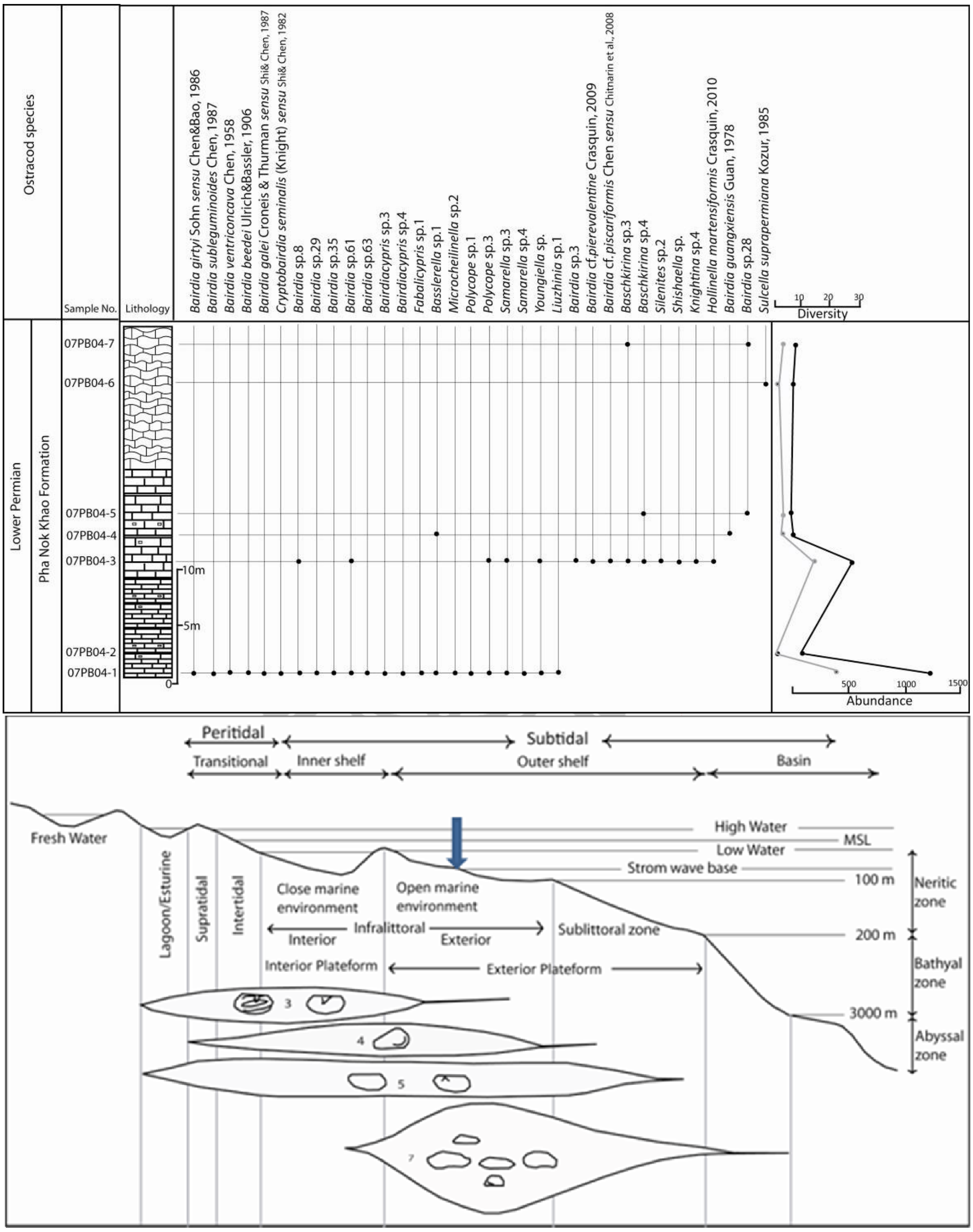

Figure 4.9 Distributions of ostracods in Nong Phai section (upper); schematic showing principle groups of Permian ostracods distributed along the continental margin (modified after Crasquin, 1984) and positions of interpreted paleoenvironments (lower).

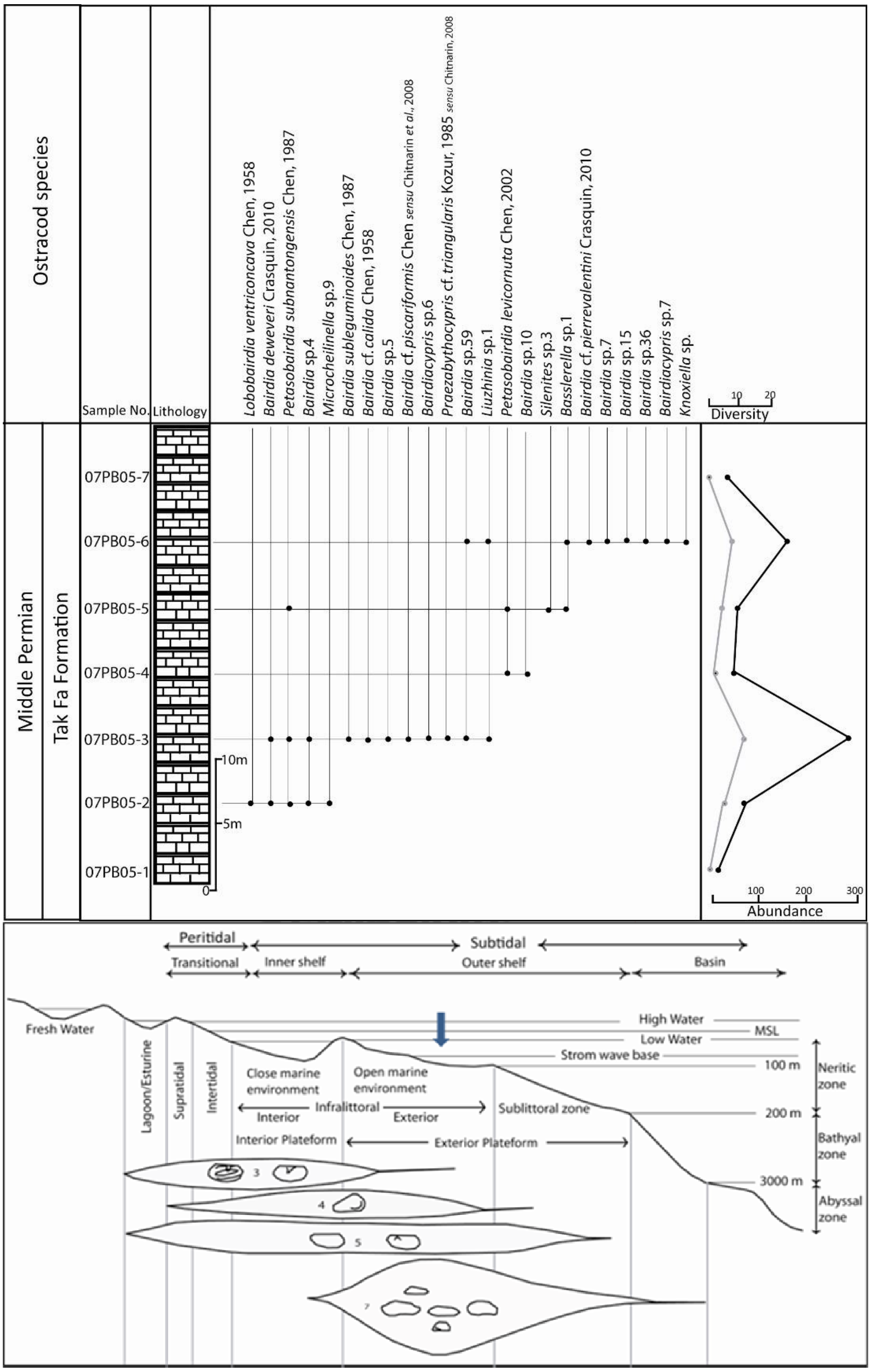

Figure 4.10 Distributions of ostracods in Ban Naen Sawan I section (upper); schematic showing principle groups of Permian ostracods distributed along the continental margin (modified after Crasquin, 1984) and position of interpreted paleoenvironment (lower).

4.4.6 Ostracod distributions in Ban Nean Sawan II section (07PB06 to 07PB08); (Figure 4.11)

From the overall 100 meter-thick section, some samples yielded ostracods which are possible for identification. The ostracod assemblages are mainly represented by Bairdioidea (66.66%). Other families are of Pachydomellidae (16.6%), Kirkbyoidea (8.33%), and Polycopidae (8.33%). The environment of deposition is open marine environment, subtidal, slightly deep water with normal salinity and high oxygen concentration.

It should be noticed that the ostracods recovered along this section are of compressed complete carapaces. Identification of the specimens are difficult, and only a few is possible. At the outcrop, the medium-to thick-bedded, gray limestones (mudstones to wackestones) show wavy beddings. It is assumed that the limestones were deposited in shallow water condition, high energy and under wave influences where the substrate was unstable and unsuitable for the ostracods. The compressed carapaces may reflect tectonic distortion or short-distance transportation.

4.4.7 Ostracod distributions in Phu Phra That section (08PB02 to 08PB03); (Figure 4.12)

At this section, the ostracod assemblages are mainly composed of Bairdioidea (46%). Other families are of Kirkbyoidea (20%), Pachydomellidae (13.33%), Cavellinidae (6.66%), Hollinoidea (6.66%), and Kloedenelloidea (6.66%). The environment of deposition is open marine, subtidal, very shallow to shallow water with high terrigenous deposits, nearshore, with wide range of salinity to normal salinity. The oxygen concentration for the overall section is about 5.2 mL/L

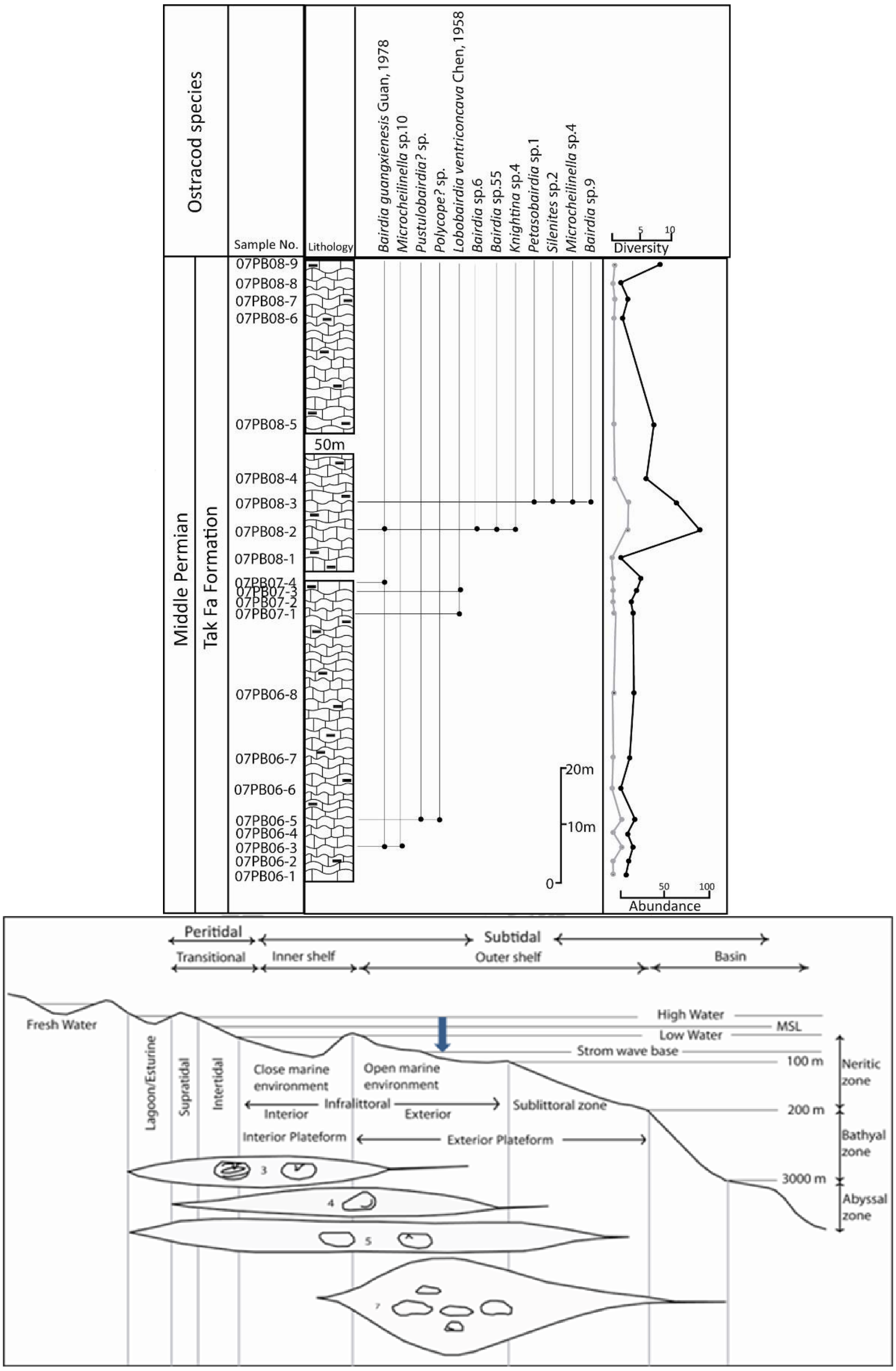

Figure 4.11 Distributions of ostracods in Ban Naen Sawan II section (upper); schematic showing principle groups of Permian ostracods distributed along the continental margin (modified after Crasquin, 1984) and position of interpreted paleoenvironment (lower).

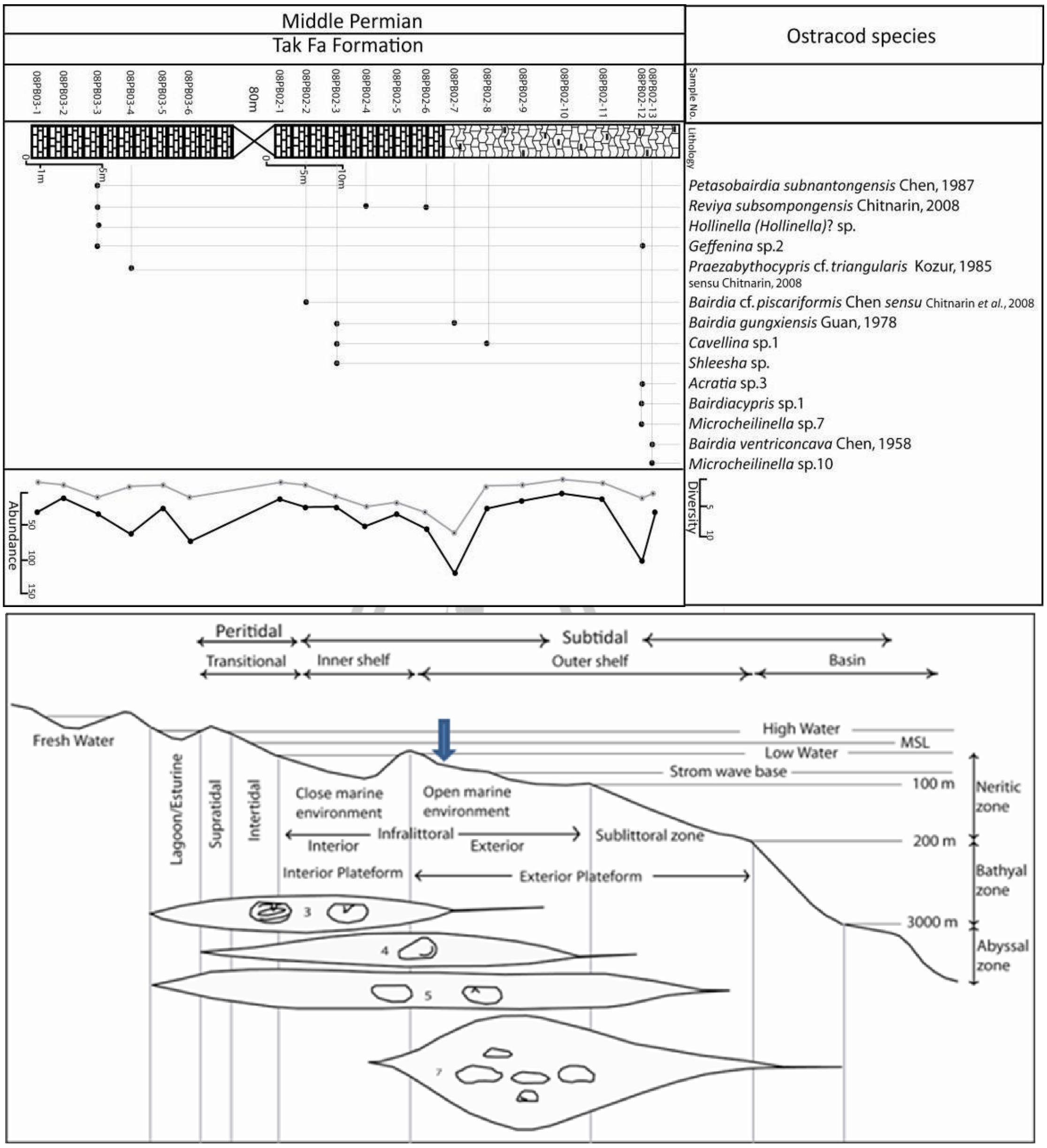

Figure 4.12 Distributions of ostracods in Phu Phra That section (upper); schematic showing principle groups of Permian ostracods distributed along the continental margin (modified after Crasquin, 1984) and position of interpreted paleoenvironment (lower).

(filter feeder is 33.2%).

It should be noted that ostracods recovered from this section are mostly of closed carapaces, but are corroded (probably from chemical process) which is obstructed for identification. In the lower part of the section, most of species preferring very shallow condition are found in dirty limestones intercalated with sitlstones. Brachiopods and bryozoa are abundant especially in siltstone layers which are usually as harden yellowish surfaces. In the upper part, most of species likely to live in deeper water which found in bedded limestones under wave influences.

4.4.8 Ostracod distributions in Phu Lam Yai section (07LB04); (Figure 4.13)

At Phu Lam Yai section, the ostracod assemblage is dominated by Bairdioidea (57.9%). Other families are of Kloedenelloidea (15.78%), Paraparchitidea (10.52%), Cavellinidae (5.26%), Hollinoidea (5.26%), and Cytherideidae (5.26%). The environment of deposition is open marine, subtidal, very shallow to shallow water with high terrigenous deposits, with wide range of salinity to normal salinity. Approximate oxygen concentrationl is 5.2-5.3 mL/L (filter feeder is 31.56%).

4.4.9 Ostracod distributions in Ta Kli section (07LB05); (Figures 4.14-4.16)

At the 07LB05 section, the ostracod assemblage is dominated by Bairdioidea (62.33%). Other families are of Pachydomellidae (10.38%), Paraparchitidea (9.09%), Kloedenelloidea (5.19%), Kirkbyoidea (3.89%), Cavellinidae, Cytherideidae and Coelonellidae (2.59% for each), Hollinoidea, Aparchitidea and Polycopidae (1.29% for each). The environment of deposition is open marine environment, subtidal, slightly deep with normal salinity. The oxygen concentration of the section is approximately 5.8 mL/L (filter feeder is 25%).

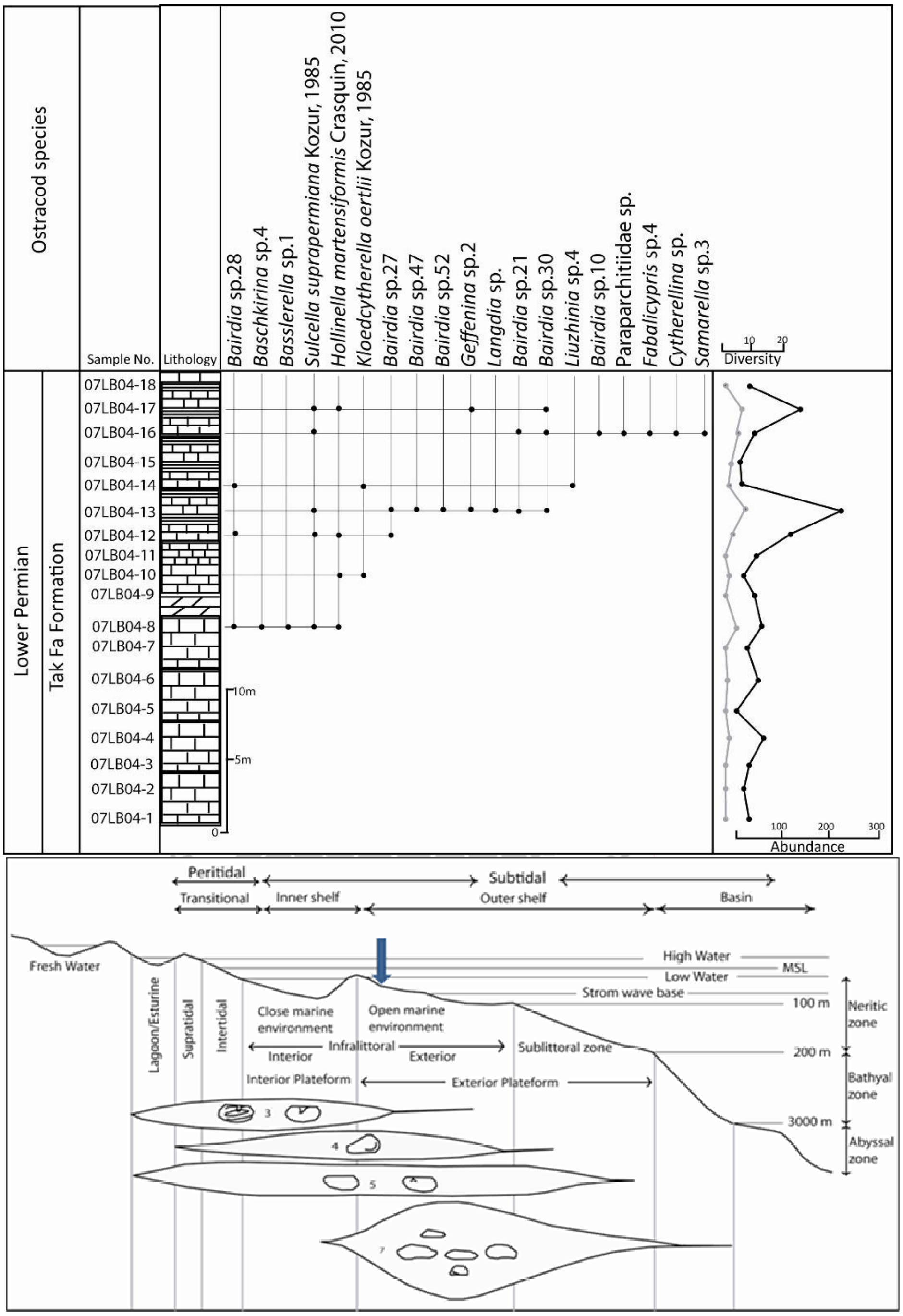

Figure 4.13 Distributions of ostracods in Phu Lam Yai section, Tak Fa District, Nakhon Sawan province (upper); Schematic showing principle groups of Permian ostracods distributed along the continental margin (modified after Crasquin, 1984) and position of interpreted paleoenvironment

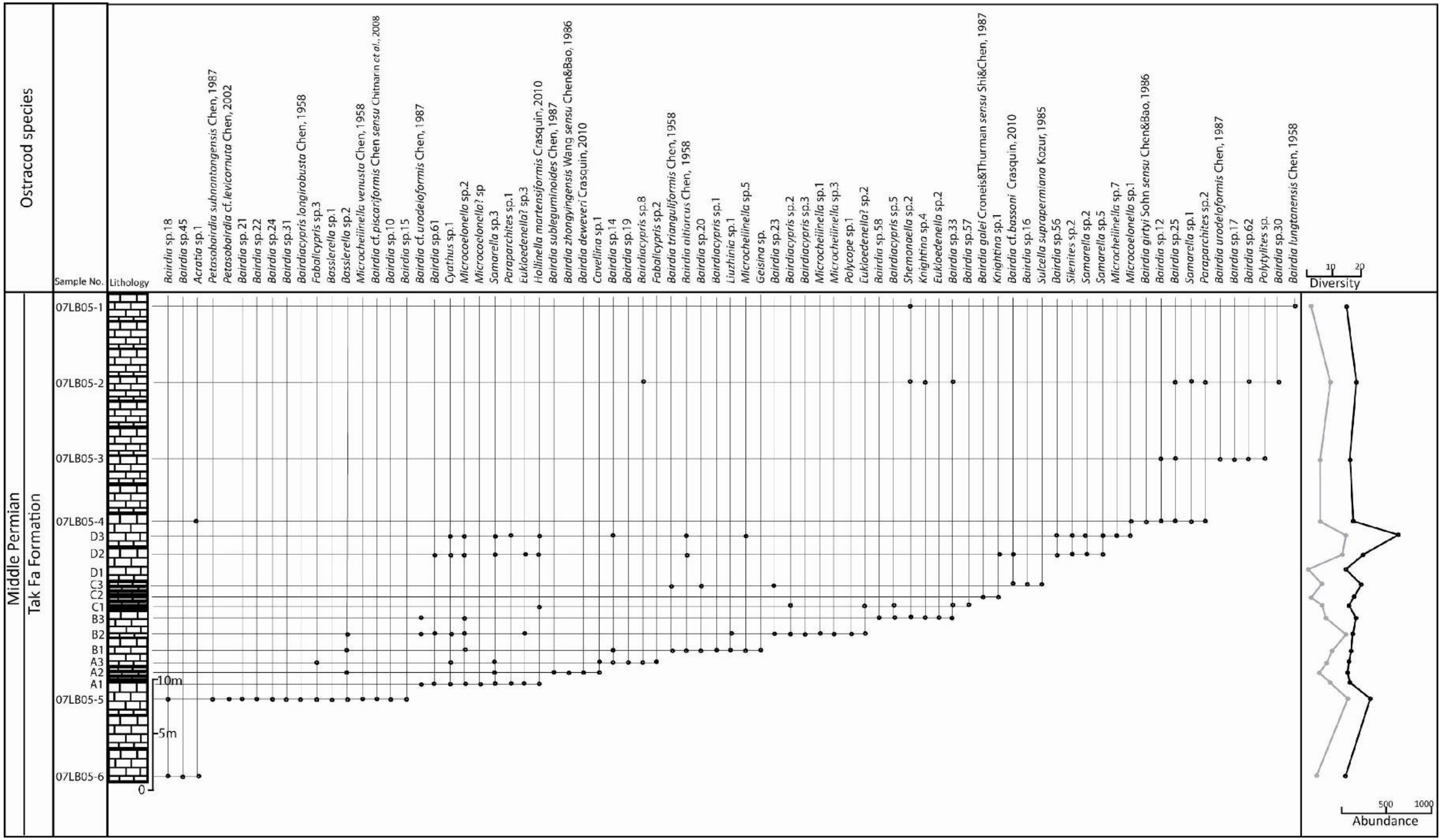

Figure 4.14 Distributions of ostracods in Ta Kli section, Ta Kli District, Nakhon Sawan Province

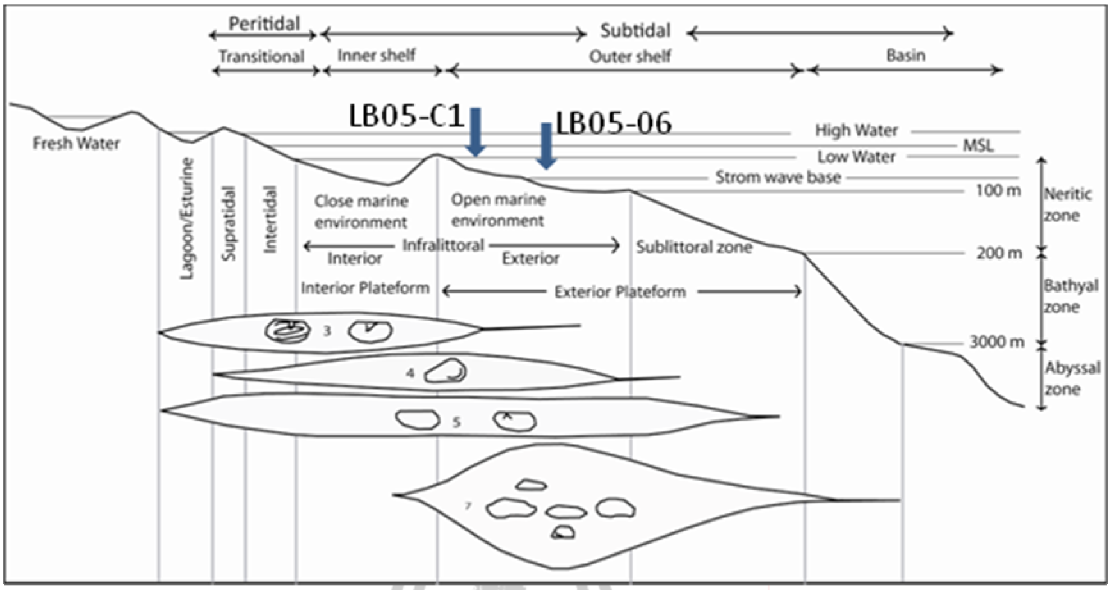

Figure 4.15 Schematic showing principle groups of Permian ostracods distributed along the continental margin (modified after Crasquin, 1984) and positions of interpreted paleoenvironments.

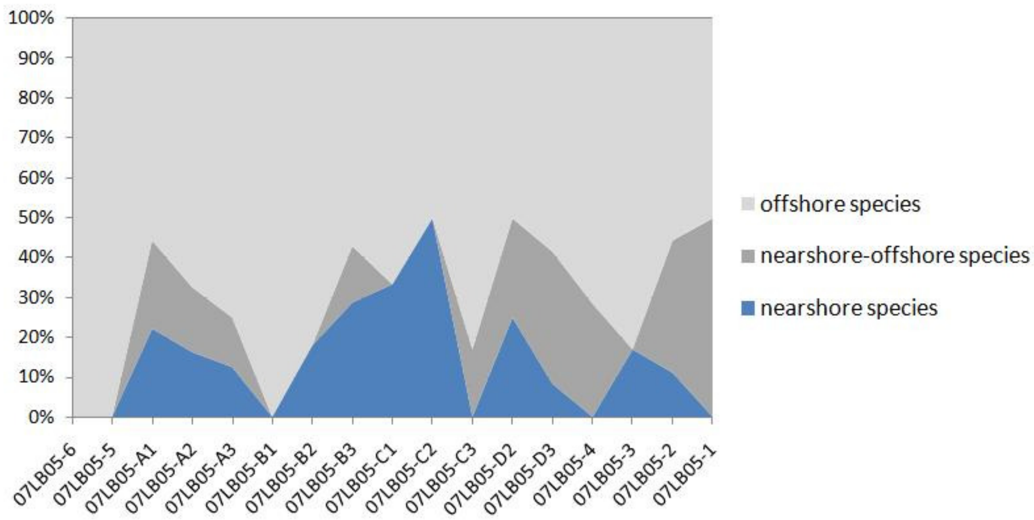

Figure 4.16 Diagram showing changes in composition of nearshore ostracods (Kloedenelloidea, Kirkbyoidea, Hollinoidea, Youngielloidea, Cavellinoidea, Polycopidae) and offshore ostracods (Bairdiidae, Pachydomellidae, Cytherideidae) along 07LB05 section.

The Ta Kli section is different from other study sections in having intercalation of thin- to medium-bedded, dark gray limestones and black shales with high content of organic matters. By the lithology, the marginal marine environments such as estuarine or lagoon were initially expected by the author; that is, terrigenous sediments containing high content of organic matters can be transported and accumulated. However, the results of high percentage of offshore species (Bairdioidea 62.33%, Pachydomellidae 10.38%, Paraparchitidea 9.09%) found along the whole section point to deeper environment (Figure 4.15 and 4.16). The oxygen concentration which should be very low as reflected by dark colour of the organic-rich limestones turns to be as high as normal marine condition. This situation at the 07LB05 section is different from the 07PB03 section where the shallow marine environment is occupied primarily by the filter feeders such as Kloedenellaceans and Kirkbyoidea. At Ta Kli section, ostracod fauna is mainly composed of Bairdioidea and Pachydomellidae (72.71%) which are likely to live farther seaward; in contrast, Kloedenelloidea and Kirkbyoidea which characterize the very shallow environment are less important. The black shales which intercalated with limestones in this section can be regarded as deep-water shales. The sea water circulation should be good causing in high oxygen concentration (5.8 mL/L) favored by the deposit feeders according to abundance of Bairdioidea.

It should be noted that most of the ostracod specimens are of complete and closed carapaces, but they are usually compressed which is due to tectonic distortiont. The presence of pyrite on the carapace surface is caused by anoxic condition during diagenesis. The abundance and diversity of this section is due to either preferable environment of the fauna or the frequency of samples collected (77 species from 18 rock samples). It is not significantly different to compare with other section; for instance, 31 species from 12 samples (08LO02), 35 species from 7 samples (07PB03).

4.4.10 General character of ostracods from Phu Chongkho locality (07LB09)

The ostracod assemblage at the 07LB09 is dominated by Bairdioidea (63%). Other families are of Paraparchitidea (15.78%), Cytherideidae, Kloedenelloidea, Hollinoidea, and Polycopidae (5.2% for each). The environment of deposition is likely to be open marine environment with normal salinity condition. The oxygen concentration of the section is approximately 5.8 mL/L (filter feeder is 21%).

4.4.11 Ostracod distributions in Khao Som Phot section (08LB01); (Figure 4.17)

The 08LB01 section, the ostracod assemblage contains the highest percentage of Bairdioidea (72.2%). Other families are of Kloedenelloidea (16.6%), Pachydomellidae (5.6%), and Cavellinidae (5.6%). The environment of deposition is open marine, subtidal, shallow water with high terrigenous deposits and wide range of salinity to normal salinity. The oxygen concentration is approximately 5mL/L (filter feeder is 27.7%).

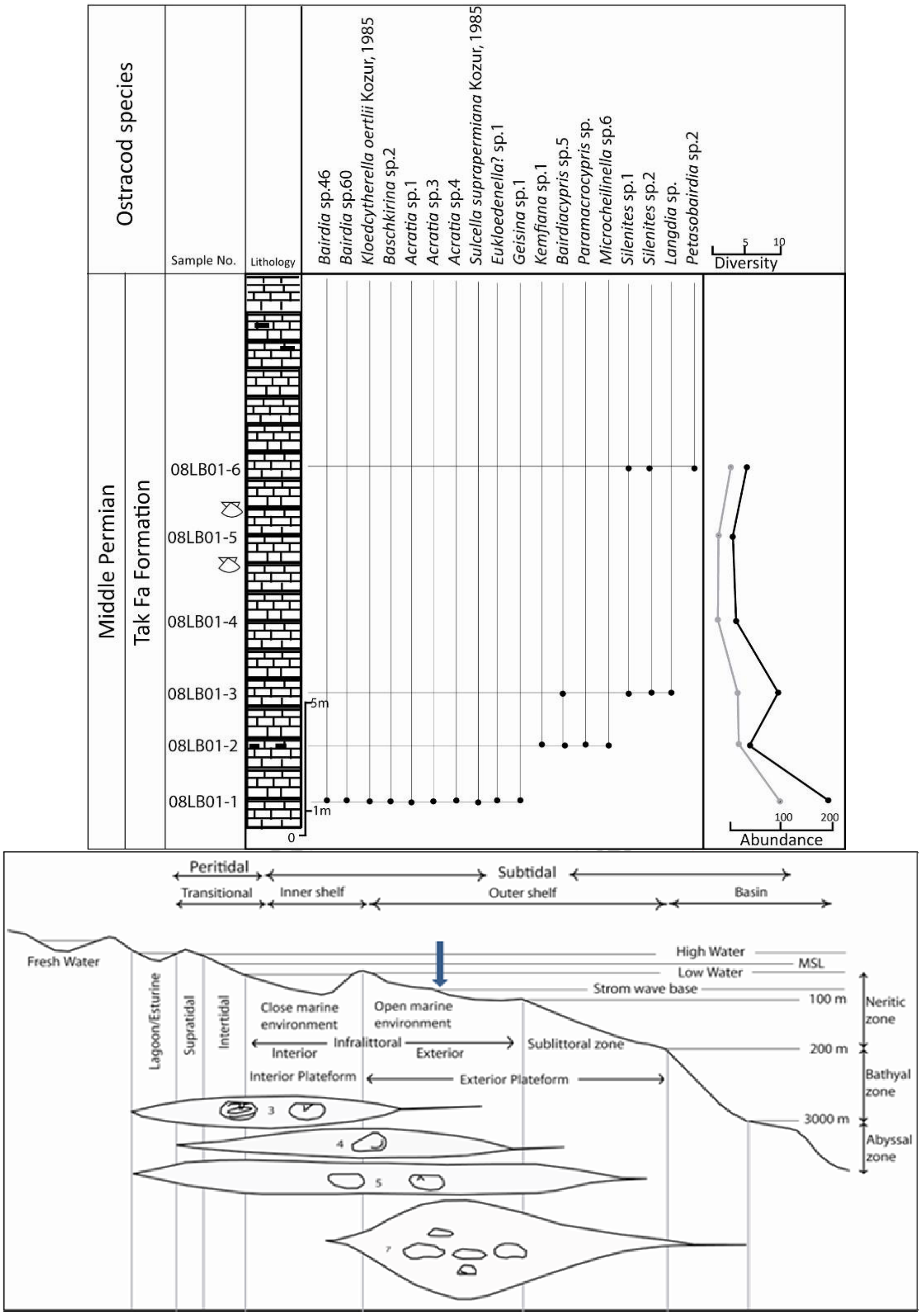

Figure 4.17 Distribution of ostracods in Khao Som Phot section (upper); schematic showing principle groups of Permian ostracods distributed along the continental margin (modified after Crasquin, 1984) and position of interpreted paleoenvironment (lower).

4.5 Conclusions on paleoecology of the studied sections according to ostracods

The main components of the Permian ostracod assemblages in this thesis are typical shallow marine species occupied marginal marine to exterior platform environments. Based on the paleoecological characteristic of ostracod families and/or superfamilies (for example, Peterson and Kaesler, 1980; Crasquin, 1984; Costenzo and Keasler, 1987; and Melnyk and Maddocks, 1988a; 1988b), the ostracod assemblages in this study can be classified into three groups: very shallow-water ostracods of intertidal zone, shallow-water ostracods of subtidal zone within interior platform, and shallow-water ostracods of subtidal zone within exterior platform. The first group is characterized by high percentage of Kloedenellids, Kirkbyellids and Hollinellids (more than 20%); for example, in sections 07PB03, 08PB02-03, 07LB04 which represent a very shallow water, with wide range of salinity, probably in estuarine/lagoonal or intertidal zone. The group that prefers living in subtidal zone within exterior platform can be characterized by high percentage of Bairdioidea (more than 70%); for example, in sections 08LO07, 07PB05, 08LB01 which suggest normal marine environment, shallow to slightly deep water with normal salinity, probably in exterior platform. The group of shallow-water ostracods living in subtidal zone within interior platform such as sections 08LO02, 07PB04, 07PB06-08 and 07LB05, ostracods are more diversified than the fore-mentioned groups, but percentage of ostracod families and/or superfamilies does not point to the shallower or the deeper environments. Other families such as Paraparchitidea, Cytherideidae, Cavellinidae, Pachydomellidae, Aparchitidea, Coelonellidae, and Polycopidae are usually associated in small percentage; this may point to the environment that suitable for many ostracods to live. It can be noticed in this study that ostracods are less recovered from limestones under wave influence. All studied sections mentioned above are belonged to the Indochina Block. In contrast, few ostracods were recovered from limestones of the Sibumasu Block (section 08KB03); paleoenvironment of deposition cannot be interpreted.

Based on the ostracods in this thesis, the paleoenvironment of the studied sections can be interpreted and summarized as followed. In Early Permian, the sections 08LO02 and 08LO07 (in the Loei area) represent open marine environment, subtidal, below wave influences, between interior and exterior platforms with normal salinity. At the same time, section 07PB03 (in the Phetchabun area) represents shallow to very shallow water, wide range of salinity whereas section 07PB04 represents deposition in subtidal zone, under wave influence within interior platform. During late Early Permian time, section 07LB04 (in the Nakhon Sawan-Lopburi area) represents shallow to very shallow water environment. During Middle Permian, section 08PB02-08PB03 (in the Phetchabun area) represent shallow to very shallow water, intertidal to subtidal zone, with wide range of salinity; section 07PB05 represents open marine environment, subtidal with normal salinity; section 07PB06-07PB08 represents deposition in subtidal zone, within interior platform, and under wave influence. In Middle Permian, section 07LB05 and 08LB01 (in the Nakhon Sawan-Lopburi area) represent open marine environment, shallow water, subtidal, slightly offshore with normal salinity.

Oxygen level in sea water can be obtained by analysis of percentage of filter-feeding vs detritivor ostracods using a model of Lethiers and Whatley (1994). All studied sections had been deposited in high oxygen level conditions (approximately more than 5 mL/L) which suggest normal marine condition. Except for Khao Kana section (07PB03) in the Phetchabun area where high percentage of filter feeders occurs and suggests very low oxygen concentration.

CHAPTER V

PALEOBIOGEOGRAPHY

The long fossil history, abundance, diversity, control on distribution by depth, temperature substrate, and lack of pelagic larvae, enable the ostracods valuable tools in paleogeographical reconstruction (Whatley, 1988). However, the occurrence of the ostracods in different places or the paleobiogeography of the fauna is important in order to understand their distribution and the geographic link during the time of deposition. Thus, this chapter is aimed to analyse the paleobiogeography of Permian ostracods from this study.

5.1 Paleobiogeography of the studied ostracods

According to Permian tectonic history of Thailand mentioned prior (see Chapter II), most of Southeast Asian areas are located on parts of Paleotethys region during the Permian. The Paleotethyan continental fragments are grouped into two well known major tectonic associations: 1) the Cathaysian terranes comprising Tarim, North China, South China, and Indochina Block and 2) the Cimmarian terranes comprising Turkey, Iran, northern Afghanistan, northern Tibet and Sibumasu Block (see Figure 2.1). These two terranes were separated by a large ocean called Paleotethys throughout much of the Permian.

Later on, the ocean was closed in the latest Permian and Triassic and formed the main landmass of this region. In Thailand, the time of the ancient ocean closure and tectonic evolution of the region are still controversial. In general, it is accepted that the country is made of an amalgamation of two different continents, the Indochina Block to the east and the Sibumasu Block to the west (see Figure 2.2); hence, the Permian faunal and floral provinces of the two blocks are different (Figure 5.1). According to previous researches (for example, Ueno, 1999; Metcalfe, 2002), limestones of the Indochina Block deposited on the western rim of the Indochina Block contain Cathaysian faunas such as fusulinacean genera *Pseudoschwagerina* sp., *Afghanella* sp., and *Yabeina* sp. These fusulinaceans had thrived on the shallow, warm-water, tropical marine region. In contrast, the limestones of the Sibumasu Block deposited on the part of the Sibumasu terrane, contain Sibumasu faunas such as fusulinaceans genera *Shanita* sp., *Monodiexodina* sp., and *Eopolydiexodina* sp.

According to the regional paleogeography mentioned above, combined with strength of ostracod fauna (mostly benthic organisms with absence of pelagic larvae), the initial hypothesis arises that the ostracods in this study should have lived and confined within the Paleotethys region. Therefore, the ostracod genera found in this research are common in Permian strata known from the warm-water Paleotethys regions; for example, South China (Chen, 1958; Chen and Shi, 1982; Chen and Bao 1986; Shi and Chen, 1987; Shi and Chen 2002; Crasquin *et al*., 2010); Hungary (Kozur, 1985); Tunisia (Lethiers *et al*., 1989); Oman (Crasquin-Soleau *et al*., 1999). In this thesis, 196 ostracod species were recovered of which 29 species (15%) have been known from other places whereas 167 species (85%) are endemic.

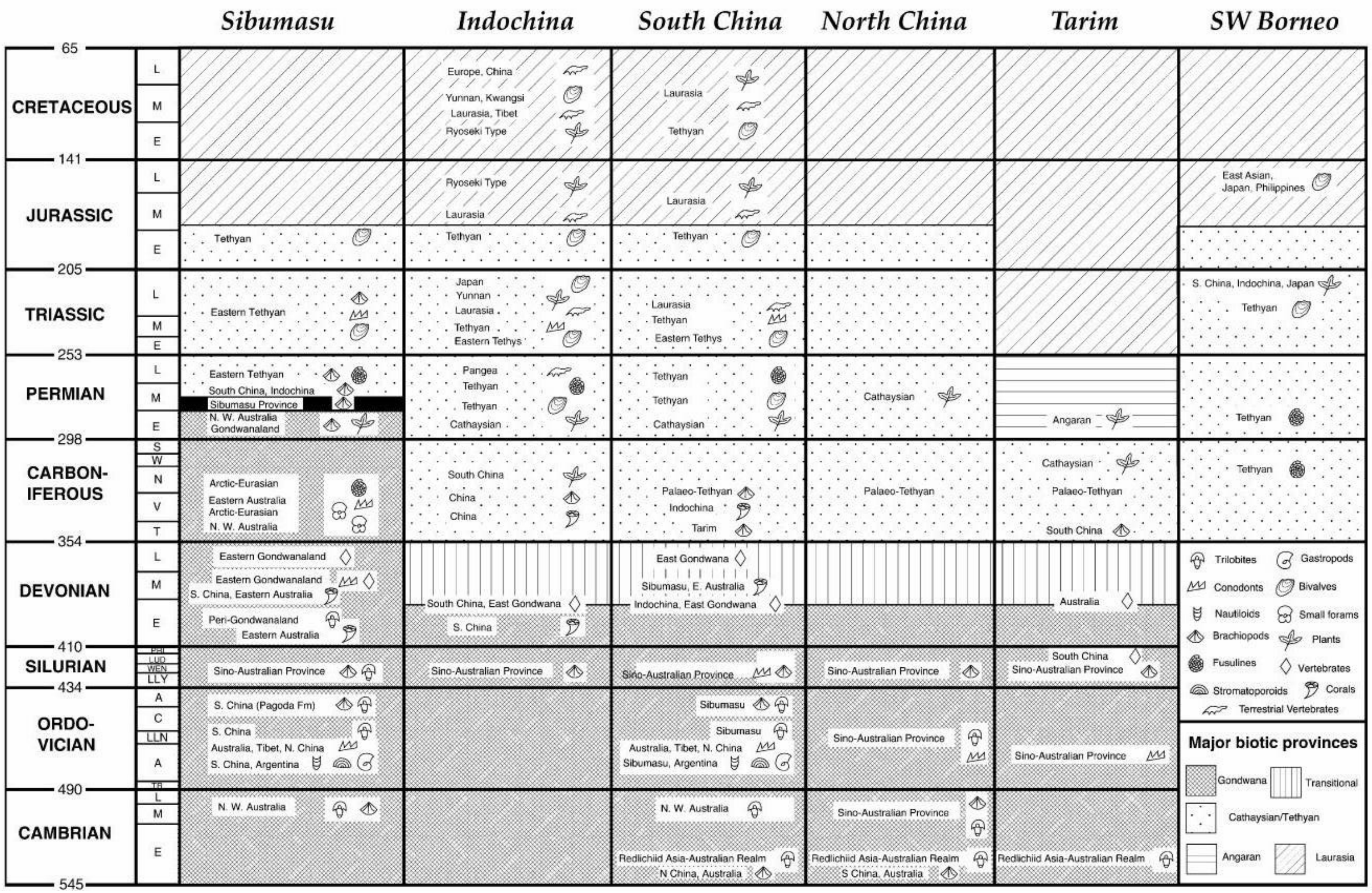

Figure 5.1 Paleozoic and Mesozoic fauna and floral provinces and fauna/floral affinities vs. time for the principal East Asian continental terranes (Metcalfe, 2002)

Figure 5.2 establishes the relationships between the Thai ostracods and the other ones from known Permian localities. There present the species names, number of common species between the known localities, and the provincialism index (*PI*) of Johnson (1971).

$$PI = C/2E_i$$

where C: number of common species between two areas

E_i: number of endemic species in the area where they are at the lowest number

Thus, the relationships of the Thai fauna are closed to those of Tunisia (*PI*=0.50). After that, in decreasing order the relationships are closed to previous researched site of Thailand (*PI*=0.25), South China (*PI*=0.09-0.19), Greece (*PI*=0.125), Oman (*PI*=0.09), Italy (*PI*=0.03), Hungary and Israel (*PI*=0.01), and the U.S.A (*PI*=0.003). The highest *PI* of 0.50 is contrast to presence of the only single species, *Hollinella (Hollina) herrickana* (Girty), 1909 in Tunisia; consequently, the closest relationships seem doubtful. The error may be due to too small number of endemic species, in this case number of endemic species of Tunisia is one. In addition, Lethiers *et al*. (1989) mentioned in their paper that fragments of other species were presented but had not been described. So, the *PI* of 0.5 is questionably accepted. The second *PI* is 0.25 which comes from study of Chitnarin *et al*. (2008) from Middle Permian of central Thailand; that was expected as the nearest site to the studied sections. The relationships with South China is interesting; *PI*=0.10-0.20 compared to Early Permian sites; *PI*=0.09-0.19 compared to Late Permian sites.

	Common species	Occurrences in studied sections of in this thesis											Th/ 2008	SC/ 1958	SC/ 1986	NC/ 1978	SC/ 1982	SC/ 1987	SC/ 2002	SC/ 2010	It/ 2008	Hun/ 1985	Tun/ 1989	USA	Gr/ 1998	Om/ 1999	Isr/ 1987
		A E	B E	C E	D E	E M	F M	G M	H E	I M	J E	K M	(1) MPr	(2) EPr	(3) EPr	(4) LPr	(5) LPr	(6) LPr	(7) LPr	(8) LPr	(9) LPr	(10) MLPr	(11) MLPr	(12) Cr-Pr	(13) EPr-LPr	(14) MPr	(15) MPr
1	*Kloedcytherella oertlii* Kozur, 1985							o	•	o												o					
2	*Reviya subsompongensis* Chitnarin, 2008							o					o														
3	*Hollinella martensiformis* Crasquin, 2010			•	•				•	o	•									o							
4	*Hollinella (Hollina) herrickana* (Girty), 1909			•																			o	o		o	
5	*Bairdia mianyangensis* Chen, 1982			•													o										
6	*Bairdia guangxienesis* Guan, 1978						o									o			o								
7	*Bairdia bassoni* Crasquin, 2010			•																o				o			
8	*Bairdia girtyi* Sohn *sensu* Chen & Bao, 1986									o					•												
9	*Bairdia lungtanensis* Chen, 1958	•		•						o				•				o									
10	*Bairdia subleguminoides* Chen, 1987				•	o												o		o							
11	*Bairdia urodeloformis* Chen, 1987									o								o		o							
12	*Bairdia beedei* Ulrich & Bassler, 1906			•	•																			o			
13	*Bairdia zhongyingensis* Wang, 1978 *sensu* Chen & Bao, 1986									o					•												
14	*Bairdia trianguliformis* Chen, 1958	•	•							o				•			o		o								
15	*Bairdia galei* Croneis & Thurman *sensu* Shi & Chen, 1987				•													o									
16	*Bairdia altiarcus* Chen, 1958									o				•					o								
17	*Bairdia deweveri* Crasquin, 2010			•		o				o										o							
18	*Bairdia hassi* Sohn *sensu* Chen & Shi, 1982						o										o										
19	*Bairdia* cf. *piscariformis* Chen *sensu* Chitnarin *et al*., 2008			•	•								o														
20	*Lobobairdia ventriconcava* Chen, 1958				•	o	o	o						•					o								
21	*Cryptobairdia seminalis* (Knight) *sensu* Shi & Chen, 1982			•	•												o										
22	*Petasobairdia subnantongensis* Chen, 1987					o		o		o								o	o	o							
23	*Petasobairdia levicornuta* Chen, 2002					o													o								
24	*Bairdiacypris longirobusta* Chen, 1958									o				•					o								
25	*Kempfina qinglaii (*Crasquin, 2008)			•																	o						
26	*Microcheilinella venusta* Chen, 1958										•			•					o	o							
27	*Pseudacanthoscapha striatula?* (Shi, 1982)		•																						o		
28	*Sulcella suprapermiana* Kozur, 1985			•					•	o		o										o			o	o	o
29	*Sulcella mesopermiana* Kozur, 1985			•																		o			o		
	Number of common species between two areas												2	6	2	1	4	5	8	7	1	3	1	3	3	2	1
	$PI=C/2E_i$												0.25	0.10	0.20	?	0.09	0.12	0.19	0.14	0.03	0.01	0.50	0.003	0.125	0.09	0.01

Figure 5.2 Relationships between the common species of Permian ostracods in this study and other known Permian localities*

***Explanation of Figure 5.2**: **Age:** EPr (E): Early Permian; MPr (M): Middle Permian; LPr (L): Late Permian. **Study sections:** A: 08LO02; B: 08LO07; C: 07PB03; D: 07PB04; E: 07PB05; F: 07PB06-07PB08; G: 08PB02-08PB03; H: 07LB04; I: 07LB05; J: 07LB09; K: 08LB01. **Previous papers:** (1) Th/2008: Central Thailand/Chitnarin *et al*., 2008; (2) SC/1958: South China/Chen, 1958; (3) SC/1986: South China/Chen and Bao, 1986; (4) NC/1978: North China/Guan, 1978; (5) SC/1982: South China/Chen and Shi, 1982; (6) SC/1987: South China/Shi and Chen, 1987; (7) SC/2002: South China/Shi and Chen, 2002; (8) SC/2010: South China/Crasquin *et al*.,2010; (9) IT/2008: Northern Italy/ Crasquin *et al*., 2008; (10) Hun/1985: Hungary/ Kozur, 1985; (11) Tun/1989: Tunisia/Lethiers *et al*., 1989; (12) USA: Girty, 1909; Kellett, 1934; Ulrich & Bassler, 1906 (number of endemic species comes from Lethiers & Crasquin-Soleau, 1995); (13) Gr/1998: Greece/Crasquin-Soleau and Baud, 1998; (14) Om/1999: Oman/Crasquin *et al*., 1999; (15) Isr/1987: Israel/Gerry et al., 1987. Legends: •: occurrence in Early Permian sites; o: occurrence in Middle and Late Permian

The *PI* also shows relationships with Greece, Oman, Italy, Hungary and Israel which located in western side of the Paleotethys. The relationships with American species are quite low.

Distributions of the benthic ostracods are mainly via the ocean floors where the ecological factors (for example, substrates, depth, temperature, salinity) are identical. The Early Permian to late Middle Permian ostracods found in this study have closed relationships with Early to Latest Permian fauna of South China; for instance, *Bairdia luntanensis* and *B. trianguliformis* originally described from the Lower Permian of South China by Chen (1958) are recovered in Lower Permian of Loei and Phetchabun areas, and occurred in Middle Permian of Nakhon Sawan-Lopburi area. *B. lungtanensis* occurs in Latest Permian of Meishan section in South China (Shi and Chen, 1987), *B. trianguliformis* is found in Late Permian of South China (Chen and Shi, 1982; Shi and Chen, 2002). Thus, this suggests connections between the Indochina Block (northeastern and central Thailand) with the South China Block at least until the late Middle Permian time.

Distributions of Permian ostracods to the remote sites within the Paleotethys can be explained by the importance of surface paleocurrents from East to West (Lethiers and Crasquin-Soleau, 1995). As shown in Figure 5.3, equatorial currents could carry ostracods to western realm of the Paleotethys. For instance, three species, *Kloedcytherella oertlii* Kozur, 1985, *Sulcella suprapermiana* Kozur, 1985, and *S. mesopermiana* Kozur, 1985, are related to Middle to Late Permian of Hungary (Kozur, 1985), Greece (Crasquin-Soleau and Baud, 1998), Israel (Gerry *et al*., 1987), and Oman (Crasquin-Soleau *et al*.,1999), one species *Hollinella (Hollina) herrickana* (Girty,1909) related to Late Permian of Tunisia (Lethiers *et al*., 1989), and one species *Kempfina qinglaii* (Crasquin, 2008) related to Late Permian of Italy (Crasquin *et al*., 2008). These ostracods are found in Early to Middle Permian of Thailand, and were recorded in Middle to Late Permian of those remote areas. So, it is possible that they originally lived in the tropical warm-water region and dispersed to the west where the ocean still opened during the Late Permian time.

5.2 Application of the Permian ostracods in local paleogeography

Look inside the Permian paleogeography of the study areas, the paleogeographic reconstruction of Wielchowsky and Young (1985) is well known and is taken into account. According to them, the Permian carbonates and siliciclastics distributed in central plain and west border of the Khorat Plateau have been divided from west to east into the Khao Khwang Platform, the Nam Duk Basin, and the Pha Nok Khao Platform, respectively (Figure 5.4). Brief information of these platforms and the basin are summarized as followed.

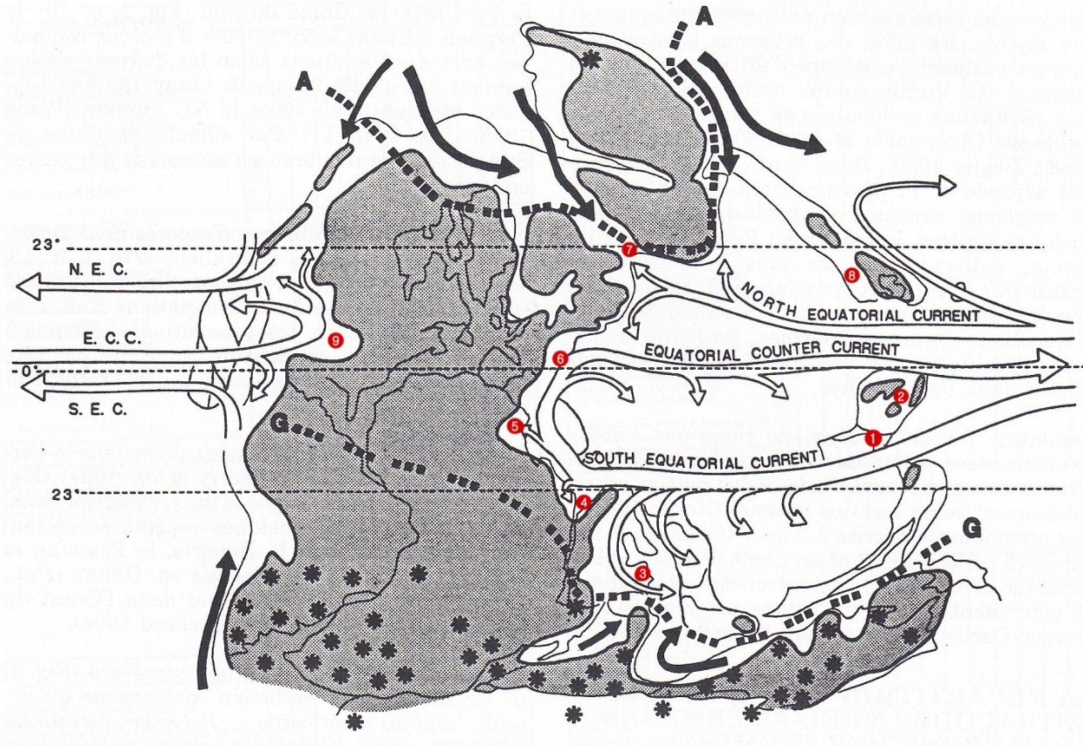

Figure 5.3 Schematic paleogeographical map during Carboniferous to Early Permian with locations of several known Permian sites relevant to this thesis* (slightly modified from Lethiers and Crasquin-Soleau, 1995)

***Explaination of Figure 5.3:** 1: Thailand (This study, Chitnarin *et al*., 2008); 2: South China (Chen, 1958, Chen and Bao, 1986, Chen and Shi, 1982, Shi and Chen, 1987, Shi and Chen, 2002, Crasquin *et al*., 2010); 3: Oman (Crasquin-Soleau *et al*., 1999); 4:Israel (Gerry *et al*., 1987); 5: Tunesia (Lethiers *et al*., 1989); 6: Hungary, Italy (Kozur, 1985, Crasquin *et al.,* 2008b); 7: Russian platform (e.g., Beloussova, 1965, Gusseva, 1971); 8 North China (Guan, 1978); 9: Late Carboniferous and Permian of North America (e.g., Girty, 1909, Kellett, 1934, Ulrich and Bassler, 1906). Thick lines: schematic Permian coastlines. Shadow: lands. White arrows: warm surface currents. Black arrows: cold surface currents. A: southern boundary of Angarian Realm. G: northern boundary of Gondwanian Realm. Slightly modified after Lethiers and Crasquin-Soleau, 1995.

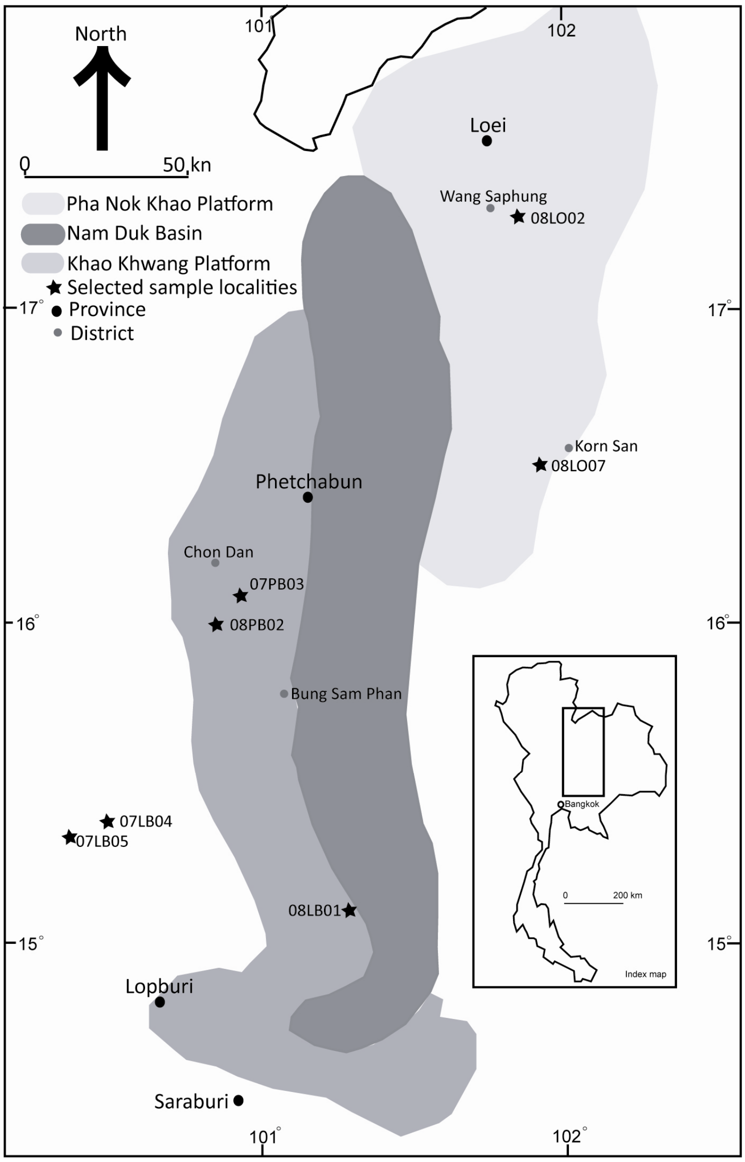

Figure 5.4 Permian paleogeographic reconstruction of central Thailand and locations of selected studied sections (modified after Wielchowsky and Young, 1985).

- The Khao Khwang Platform

The Khao Khwang Platform covers areas north of Saraburi to north of Phetchabun Provinces, and is dominated mainly by carbonate rocks of the Permian Saraburi Group with minor siliciclastic and volcanic-clastic sedimentary rocks. The rock strata were accumulated in three main depositional environments including outer platform, platform interior and restricted platform (Wielchowsky and Young, 1985). The age of this platform ranged from Asselian to Capitanian (Altermann, 1989; Chonglakmani and Fontaine, 1990). The Carboniferous rocks including shales and limestones underlying the Permian rocks are probably the oldest marine rocks on this platform. The Late Triassic rocks including basal conglomerates overlies on the Permian rocks of the Khao Khwang Platform with significant unconformity. The platform was probably terminated by influence of a marine regression event in the Late Permian. Fossil woods, possibly of Late Permian time, have been found on this platform as mentioned by Chonglakmani and Fontaine (1990).

- The Nam Duk Basin

The Nam Duk Basin extends as a longitudinal area from northeast of Saraburi Province in the south to southwest of Loei Province in the north, and is situated between the Pha Nok Khao and the Khao Khwang Platforms. The rocks of this basin comprise of carbonates and clastics such as shales, cherts, sandstones, conglomerates, and limestones which were deposited in different environments (Helmcke, 1982; Wielchowsky and Young, 1985). According to the latter authors, the rocks bounded within this basin can be divided into two groups, the carbonate and the siliciclastic facies. The carbonate facies represented by thin-bedded shales, cherts, and graded limestones were interpreted to be deposited in basin plain environment whereas graded limestones, shales, and fine-grained sandstones, limestone conglomerates and breccias were interpreted to basin margin environment. The siliciclastic facies can be divided into three groups according to the depositional environments. The rocks deposited in deep marine environment comprise of graywackes and shales with complete Bouma sequences and convoluted bedding. The rocks deposited in shallow marine are of shales, siltstones, cross-laminated sandstones and minor limestones. The rocks deposited in marginal marine environment consist of sandstones, conglomerates, shales and limestones with primary structures and plant materials. The age of the rocks in the Nam Duk Basin can be designated to Early to late Middle Permian or about Asselian to late Guadalupian age (Helmcke and Kraikhong, 1982; Wielchowsky and Young, 1985; Altermann, 1989).

- The Pha Nok Khao Platform

The Pha Nok Khao Platform covers area of Loei Province from Chumphae District in the south to Chiang Khan District in the north. This carbonate platform developed on a distally steepened ramp-like margin and was accumulated in three environments; restricted platform, platform interior and outer platform. Based on fusulinaceans, the age of this platform is early Asselian to late Guadalupian (Wielchowsky and Young, 1985).

The studied sections are located on the Khao Khwang and the Pha Nok Khao Platforms; although, the limestones of the Nam Duk basin were excluded from this study due to their unfavoured depositional facies for ostracods. Apart from Wielchowsky and Young (1985), the Permian paleogeography of this region has later been interpreted by several authors. Some disagreements have arised for the presence of these platforms and basin; for example, were two platforms connected and located eastward and were separated by tectonic process (Helmcke, 1994)?; have we two different platforms originally which sloped to the east and the west to the deep basin located in between (Tabakh and Utha-Aroon, 1998). In order to see the relationships between these two platforms, presence of the studied ostracods on both platforms were taken into account (Table 5.1).

Table 5.1 Occurrences of common species on the studied sections. C = number of common species; * = species found on the Pha Nok Khao and the Khao Khwang Platforms.

	Study area	LO				PB					LB				K	C
	Ostracod species	01	02	05	07	03	04	05	06-08	82-83	04	05	09	81	03	
1	*Cyathus* sp.1*				+		+					+				3
2	*Cyathus* sp.2						+					+				2
3	*Knoxiella* sp.2					+		+								2
4	*Langdaia* sp.1										+			+		2
5	*Geisina* sp.1					+						+				2
6	*Eukloedenella?* sp.1												+	+		2
7	*Kloedcytherella oertlii* Kozur, 1985									+	+					2
8	*Paraparchites* sp.1*	+	+									+				3
9	*Samarella* sp.1											+	+			2
10	*Samarella* sp.3*				+		+				+	+	+			5
11	*Samarella* sp.4						+						+			2
12	*Knightina* sp.4						+		+			+				3
13	*Reviya subsompongensis* Chitnarin, 2008									+						2
14	*Polytylites* sp.*				+							+				2
15	*Kellettina* sp.					+	+									2
16	*Permoyoungiella* sp.*		+				+									2
17	*Hollinella martensiformis* Crasquin, 2010					+	+				+	+	+			5
18	*B. lungtanensis* Chen, 1958 *		+			+						+				3
19	*B. subleguminoides* Chen, 1987						+	+								2
20	*B.* cf. *urodeloformis* Chen, 1987*				+							+				2
21	*B.* cf. *calida* Chen, 1958					+		+								2
22	*B. beedei* Ulrich & Bassler, 1906					+	+									2
23	*B. trianguliformis* Chen, 1958 *		+		+							+				3
24	*B. galei* Croneis & Thurman *sensu* Shi & Chen, 1987						+					+				2
25	*B. deweveri* Crasquin, 2010					+		+				+				3
26	*B.* cf. *piscariformis* Chen *sensu* Chitnarin *et al.,* 2008					+	+									2
27	*Bairdia sp.* 3					+	+									2
28	*Bairdia sp.* 4*		+					+						+		3
29	*Bairdia sp.* 7					+		+								2
30	*Bairdia sp.* 10					+		+				+				3
31	*Bairdia sp.* 12											+		+		2
32	*Bairdia sp.* 14											+		+		2
33	*Bairdia sp.* 17											+		+		2
34	*Bairdia sp.* 19*				+							+				2
35	*Bairdia sp.* 29					+					+					2
36	*Bairdia sp.* 30										+					1
37	*Bairdia sp.* 35*		+		+		+					+				4
38	*Bairdia sp.* 38*		+		+											2
39	*Bairdia sp.* 42*		+		+											2
40	*Bairdia sp.* 43*		+										+			2
41	*Bairdia sp.* 44*	+			+											2
42	*Bairdia sp.* 61*		+				+					+				3
43	*Lobobairdia ventriconcava* Chen, 1958						+	+	+	+						4
44	*Cryptobairdia seminalis* (Knight) *sensu* Shi & Chen, 1982					+	+									2
45	*Petasobairdia subnantongensis* Chen,1987							+		+		+				3
46	*Bairdiacypris* sp. 1										+	+				2
47	*Bairdiacypris* sp. 2*											+		+		2
48	*Bairdiacypris* sp. 4*				+		+									2
49	*Bairdiacypris* sp. 5										+	+		+		3
50	*Bairdiacypris* sp. 6*				+			+								2
51	*Bairdiacypris* sp. 7					+		+								2
52	*Bairdiacypris* sp. 8										+	+				2
53	*Silenites* sp.2*		+				+		+			+		+		5
54	*Liuzhinia* sp.1					+						+	+			3
55	*Acratia* sp.1*				+	+						+		+		4
56	*Acratia* sp.3*				+	+	+			+			+	+		6
57	*Acratia* sp.4*				+									+		2
58	*Baschkirina* sp. 4*		+			+	+					+				4
59	*Microcheilinella* sp.2*				+		+									2
60	*Basslerella* sp.1*				+	+	+	+			+	+	+			7
61	*Basslerella* sp.2*		+									+				2
62	*Cavellina* sp.1					+						+				2
63	*Sulcella suprapermiana* Kozur, 1985					+					+	+		+		4
64	*Polycope* sp.1*		+				+		+							3
65	*Polycope* sp.3*		+				+						+			3

As shown in Table 5.1, there are 65 common species found in this research of which 28 species are found across the Nam Duk Basin. Based on paleoecological characteristics of the ostracod families and/or superfamilies (Melnyk and Maddocks, 1988a; 1988b), the groups living slightly offshore appear to be able to disperse farther than the groups living in nearshore environment. Though, the latter group seems to be a significant criterion to determine the former juxtaposition areas. Truthfully, all the benthic ostracods living along the continental margin and their benthic larvae are not able to cross the paleogeographic barrier such the deep basin as the Nam Duk Basin in this case. In this study, *Polytylites* sp. (Kirkbyoidea), *Paraparchites* sp.1, and *Samarella* sp.3 (Paraparchitidea) are evidences of shallow-water inhabitants which found on both platforms. *Paraparchites* sp.1 is occurred from the earliest to late Middle Permian (Asselian and Midian) on the Pha Nok Khao Platform, and occurred in Middle Permian on the Khao Khwang Platform. *Samarella* sp.3 and *Polytylites* sp. are found in Early Permian of the Pha Nok Khao and in Early and Middle Permian of the Khao Khwang Platform. In addition, members of Bairdioidea (*Bairdia* sp., *Acratia* sp., *Bairdiacypris* sp., *Silenites* sp., *Baschkirina* sp.), Aparchitidae (*Cyathus* sp.), and Cytherideidae (*Basslerella* sp.) are commonly found on both platforms. The associate ostracods are of small to large size; thus, the accidental transportation is unlikely. In contrast, the common species are less of Hollinoidea and Kloedenelloidea which characterized very shallow, nearshore environment.

According to this study, it is concluded here that the Permian limestones of the Khao Khwang and the Pha Nok Khao Platforms were deposited not very far from each other where the ecological factors were identical which enabled the benthic ostracods to travel or migrate. The Permian paleogeographic interpretation of

Wielchowsky and Young (1985) is favoured. The possible pathway of ostracod migration is the Saraburi area where lithostratigraphy of the southward extension of the Nam Duk Basin shows evidences of the shallower environment of deposition. Forthcoming intensive research should be carried out in the Saraburi area.

5.3 Conclusion on paleobiogeography

Permian ostracods recovered in this thesis are of Early to late Middle Permian age which comprised of genera commonly found in warm water, shallow marine environments. There are 196 species belonged to 41 genera of which 29 species are known from other Permian sites within Paleotethys region. Provincial index (Johnson, 1970) suggests the closed relationships mainly with South China, and less with Tunesia, Greece, Oman, Italy, Hungary, Israel, in descending order. The relationships with North American species are low. The dispersion of common species in this study suggests that the Permian limestones of the Khao Khwang and the Pha Nok Khao Platforms were deposited not very far from each other where the ecological factors were identical that enabled the benthic ostracods to travel or migrate.

CHAPTER VI

DISCUSSIONS AND CONCLUSIONS

In this thesis, Early to late Middle Permian ostracods were recovered from twelve sections and two localities spread out northeastern, central, and western Thailand (the Loei, the Phetchabun, the Nakhon Sawan-Lopburi, and the Kanchanaburi areas). Taxonomy, paleoecological interpretations, and paleobiogeography of Permian ostracods in Thailand have been carried out and established. Nevertheless, there are some points to be discussed and concluded here.

6.1 Discussions on general geology and stratigraphy of the studied sections

Permian rocks of Thailand are extensively exposed throughout the country except on Khorat Plateau, and they are different in lithology and sedimentary facies. Lithostratigraphy of the Permian rocks in Thailand have been reviewed by Assawapatchara *et al*. (2006); thus, the general geology and stratigraphy of the studied sections are primarily based on their work. Other information and materials come from 1) geological maps on scale 1:250,000, 2) geological reports on scale 1:50,000 conducted by Department of Mineral Resources, 3) publications and previous works of several authors at or nearby the studies sections (see Chapter II). Besides, tectonic of Thailand is based mainly on Ueno (2002). There were three reasons for choosing the studied sections in the Loei, the Phetchabun, the Nakhon Sawan-lopburi, and the Kanchanaburi areas: 1) the areas cover parts of northeastern, central, and western Thailand where information of Permian ostracods are rare; 2) they comprise limestones of the Sibumasu and Indochina Blocks which range from Early to late Middle Permian; 3) their locations are easily accessible.

The important constrain of this research is age determination. Although, fusulinacean fauna plays an important role on Permian biostratigraphy in Thailand (for example, Dawson and Racey, 1993); they were not observed in every studied sections. The precise ages can be designated to some studied sections whereas tentative ages determined by correlations with nearby localities of known age or compared with associated fossils were designated for the other sections.

6.2 Discussions on systematic paleontology

The studied ostracods were extracted from limestones by using concentrate acetic acid following the hot acetolysis method (Lethiers and Crasquin-Soleau, 1988; Crasquin-Soleau *et al*., 2005). The results are successful; in other words, 9,188 specimens were isolated. Most of ostracod specimens are complete and neat, they are good enough for scanning electron photography (with and without gold coating). Some difficulties such as intraspecific and geographic variations, taphonomic variability, and corrosion from acid during extraction obstructed the systematic study.

Rare information of ostracods in Southeast Asia is another problem. One example is the similarity of the studied ostracods with ostracods known from different ages. *Bairdia* sp.10 found from Khao Kana section (07PB03), Ban Naen Sawan I section (07PB05) and Ta Kli section (07LB05) is very similar to *B. naumarae*

Yegorov, 1965 described from Frasnian (the Devonian) in Russia (Yegorov, 1965). Any interpretation cannot be made at present because Devonian ostracods in Thailand have never been investigated. Some species are attributed here to species with open nomenclature. Although, they are closed to previously identified species, they have some different characters which may be due to intraspecific or geographic differences of the species. These points should be considered or proved in future work.

6.3 Discussions on paleoecological interpretation

Interpretations on paleoecology of ostracod assemblages and paleoenvironments of the studied sections were completed by using the paleoecological characteristic of ostracod families and/or superfamilies and a model analysis of oxygen level in sea water (see Chapter IV). It is observed in this study that paleoecology and paleoenvironment suggested by ostracod assemblages are concordant with lithology, sedimentary structure, associated fossils, and previous studies (Table 6.1). Ostracod bearing limestones can be classified to mudstone, wackestone, packstone, and are usually micritic limestones. In contrast, the ostracods were rarely recovered from dolomitic and crystalline limestones. Members of Kloedenellidae and Kirkbyidae, representatives of very shallow water with high terrigenous deposits, are usually found in dirty, micritic limestones intercalated with shales with association of small foraminiferas and brachiopods (07PB03, 08PB02-08PB03, and 07LB04 sections). Members of Bairdioidea usually found offshore are often linked with micritic and argillaceous limestones (sometimes intercalated with black shales) with association of fusulinaceans; for example, 08LO02, 08LO07, 07PB04, 07PB05, 07LB05 sections. The interpretations of paleoenvironment with

Table 6.1 Comparisons between paleoenvironment with reference to ostracod assemblages and previous studies

Studied section	Dominant group	Substrate	Salinity	Depth	Environment of deposition reference to ostracods	O_2 (mL/L)	Lithology	Limestone classification	Interpretation of previous studies
08LO02	B (58%)	f, cal mud	norm	sh	open marine, subtidal, proximal of exterior platform	5.5	light gray, cry lst	wackestone-packstone	Intertidal to subtidal (Assawapatchara, 1999)
08LO07	B (79%)	f, cal mud	norm	deep	open marine, subtidal, offshore	>6	drak grey, arg lst	wackestone-packstone	shallow marine, carbonate platform (Wongprayoon and Seangsrichan (2009)
07PB03	B (69%) Kl (100%)	f, cal mud f, ter mud	w-r to norm	vsh- sh	open marine, peritidal-subtidal, high terrigenous sediments	5.2	dark gray, mic lst	wackestone	none
07PB04	B (67%)	f, cal mud	norm	deep	open marine, subtidal, under wave influence	5	gray-light gray, arg-cry lst	wackstone-packstone	none
07PB05	B (86%)	f, cal mud	norm	deep	open marine, subtidal, offshore	>6	dark gray, arg lst	mudstone-wackestone	none
07PB06-08	B (67%)	f, cal mud	norm	deep	open marine, subtidal, under wave influence	>6	light gray, cry lst	mudstone-wackestone	none
08PB02-03	B (46%) Kb (20%)	f, cal mud f, ter mud	w-r to norm	sh	open marine, subtidal, nearshore, high terrigenous deposits	5.2	dark gray-gray, arg-mic lst	wackstone-packstone	none
07LB04	B (58%) Kl (16%)	f, cal mud f, ter mud	w-r to norm	sh	open marine, subtidal, nearshore, high terrigenous deposits	5.3	gray, arg-mic lst	mudstone-wackestone	none
07LB05	B (63%)	f, cal mud	norm	deep	open marine, subtidal, offshore	5.8	dark gray, arg lst	wackstone-packstone	carbonate platform, from deep to shallow water (Assawapatchara, 2004)
07LB09	B (63%)	f, cal mud	norm	deep	open marine, subtidal, slightly offshore	5.8	light gray, cry lst	wackstone-packstone	none
08LB01	B (72%) Kl (17%)	f, cal mud f, ter mud	norm	sh-deep	open marine, subtidal, high terrigenous deposits	5	dark gray, mic lst	wackstone-packstone	Intertidal to shallow subtidal (Udchachon, 2007)

reference to ostracod assemblages at 08LO02, 08LO07, 07LB05 sections correspond with previous studies, except for 08LB01 section. Results on microfacies suggest the deposition in very shallow marine, peritidal, in restricted lagoon for the lower part of Khao Som Phot section (08LB01) during late Wordian to Capitanian (Udchachon, 2007). According to this research, high percentage of Bairdioidea points to open marine, subtidal with high terrigenous deposits. Carapaces of the Bairdioidea are tumid and thick whereas carapaces of the Kloedenellidae are elongate but delicate. These morphologies ensure slightly offshore in open marine environment. This is contrast to ostracods found from Khao Kana section (07PB03) in the Phetchabun area where the environment of deposition was interpreted as very shallow water, possibly intertidal. The Kloedenellidae occupied 100% at level 07PB03-4, and their carapaces are thick and robust.

Oxygen concentration of sea water can be obtained by analysis of percentage of filter-feeding vs deposit-feeding ostracods using a model of Lethiers and Whatley (1994). All studied sections had been deposited in high oxygen level conditions (approximately more than 5 mL/L) which suggest normal marine condition. Except for 07PB03 section where high percentage of filter feeders (Kloedenellidae, Kirkbyoidea, and Cavellinidae) occurs and suggests very low oxygen concentration. It can be observed along the section that percentage of the filter-feeding ostracods changed from 30%, 33%, 100%, 54% and 20% in 07PB03-1, -3, -4, -5 and -7, respectively. This means that the oxygen concentration varied from normal marine condition to very low oxygen (less than 3 mL/L) and recovered to normal marine condition again. At level 07PB03-4, the filter-feeding ostracods reach 100%, all of them belong to Kloedenelloidea which suggest very low oxygen concentration.

According to the model of Lethiers and Whatley, 100% of filter feeders may suggest the oxygen concentration lower than 1 mL/L. In fact, diversity and abundance of ostracods decreased at 07PB03-4 (compared with 07PB03-3) but there are almost 200 specimens recovered. Hence, the presence of 100% filter-feeding ostracods should not reflect the anoxic condition or totally lack of oxygen because in that critical condition, no life should be able to survive. In this case, it should suggest very low oxygen concentration, high terrigenous sediments, or high tolerance of the Kloedenellacean in such a hard condition within a short period.

6.4 Discussions on paleobiogeography

The studied ostracods have relationships with other Permian sites in Paleotethys region especially with South China; although, most of them (85%) are endemic. The endemism of Thai fauna may be due to lack of ostracod information in Southeast Asia, most of previous works were carried out in South China which enable for comparison at present. The relationships with Chinese fauna are higher compared with those in western rim of Paleotethys (Greece, Oman, Italy); this may suggest that there was an oceanic pathway between central Thailand and South China at least until late Middle Permian. Though, infrequent dispersion from eastern Paleotethys to western Paleotethys may be explained by a model of Lethiers and Crasquin-Soleau (1995).

6.5 Conclusions

Several field works on Early to late Middle Permian rocks were carried out in

Loei, Phetchabun, Nakhon Sawan-Lopburi, and Kanchanaburi areas in order to investigate their geology, stratigraphy and to collect limestone samples. 218 samples (181 from 15 measured sections and 2 localities, and 37 from preliminary study) were processed by the hot acetolysis (Lethiers and Crasquin-Soleau, 1988; Crasquin-Soleau *et al.*, 2005). As a result, limestones of the Indochina Block (Loei and Saraburi Groups) yielded many ostracods whereas limestones of the Sibumasu Block (Sai Yok Limestone) yielded very few ostracods. Totally, the recovered ostracods are belonged to 196 species and 41 genera of which 29 species are known from other places, 167 species are endemic.

The ostracod assemblages are composed of typical shallow marine species from marginal marine to exterior platform environments which belonged to Bairdioidea, Kloedenellidae, Kirkbyidae, Hollinellidae, Paraparchitidea, Cytherideidae, Cavellinidae, Pachydomellidae, Aparchitidea, Coelonellidae, and Polycopidae. Interpretation of paleoenvironment is based on the paleoecological characteristic of ostracod families and/or superfamilies (e.g., Peterson and Kaesler, 1980; Crasquin, 1984; Costenzo and Keasler, 1987; and Melnyk and Maddocks, 1988a, b). In the Loei area, Tham Nam Maholan and Sak Chai Quarry sections represent open marine environment, subtidal zone, below wave influences, from interior to exterior platforms with normal salinity during the Early Permian. In the Phetchabun area, Khao Kana section represents very shallow to shallow water, with wide range of salinity and high terrigenous deposits whereas Nong Phai section represents deposition in subtidal, under wave influence, normal salinity within interior platform during Early Permian. In early Middle Permian, Phu Pra That and Ban Naen Sawan I sections represent very shallow to shallow water, intertidal to subtidal whereas Ban Naen Sawan II represents open marine environment, subtidal zone, within interior platform, and under wave influence. In the Nakhon Sawan-Lopburi area: Phu Lam Yai section represents a very shallow water environment in intertidal zone during late Early Permian; Ta Kli section represents open marine environment, subtidal, slightly deep water with high contents of organic matters during Middle Permian; Khao Som Phot section probably represents deposition in open marine environment, subtidal with normal salinity in exterior platform during late Middle Permian. Oxygen level in sea water is obtained by analysis of percentage of filter-feeding and deposit-feeding ostracods using a model of Lethiers and Whatley (1994); as a result, oxygen concentration is approximately 5mL/L at all sections.

Permian ostracods recovered are 196 species belonged to 41 genera of which 29 species are known from other Permian sites within Paleotethys region. All the forms are benthic inhabitants and their larvae have the same way of life. Provincialism Index (Johnson, 1970) suggests close relationships mainly with South China, and Tunisia, Greece, Oman, Italy, Hungary, Israel, in decreasing order. The relationships with North American species are low. The common species between the Loei, the Phetchabun, the Nakhon Sawan-Lopburi areas suggest that limestones of Indochina Block (Loei and Saraburi). The limestones were deposited in shallow marine environments not far from each other where benthic ostracod fauna was able to travel or migrate.

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APPENDIX

APPENDIX

ALPHABETIC INDEX OF IDENTIFIED SPECIES

IN THIS THESIS

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PLATES

Plate 1

(Scale bar is 500 µm except for 3, 8, 13-15, 17-18, 20-22 where it is 300 µm)

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Figure 9-10 *Bairdia girty* Sohn *sensu* Chen & Bao, 1986; 9 right lateral view of the complete carapace, SUT-09-1009, sample 07PB04-2; 10 right lateral view of the complete carapace, SUT-09-1010, sample 07PB04-2.

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Figures 17-18 *Bairdia urodeloformis* Chen, 1987; 17 right lateral view of the complete carapace, SUT-09-1017, sample 07LB05-3; 18 right lateral view of the complete carapace, SUT-09-1018, sample 07LB05-3.

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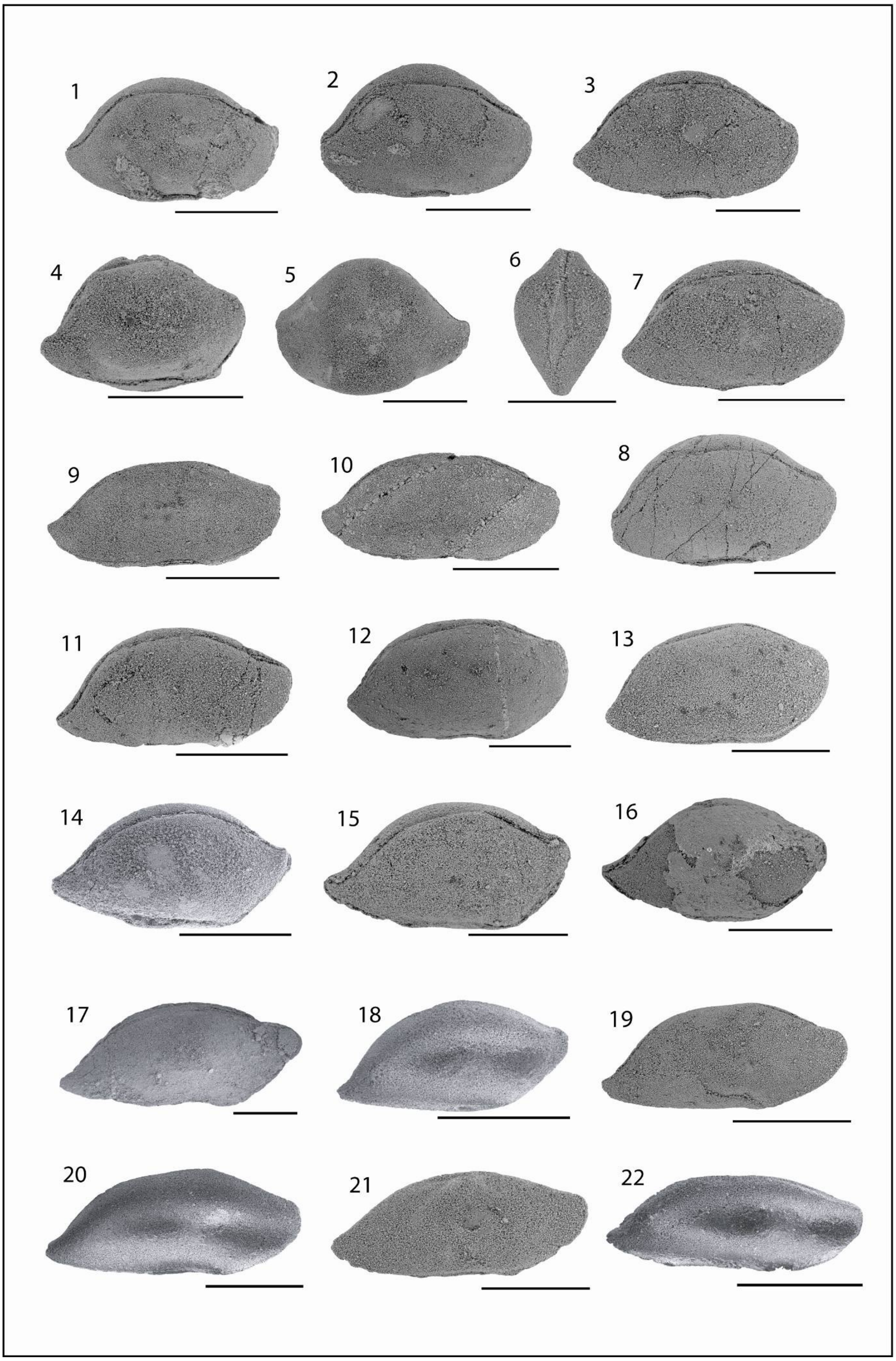

Plate 2

(Scale bar is 500 µm except for 3, 7-11, 13-14 where it is 300 µm)

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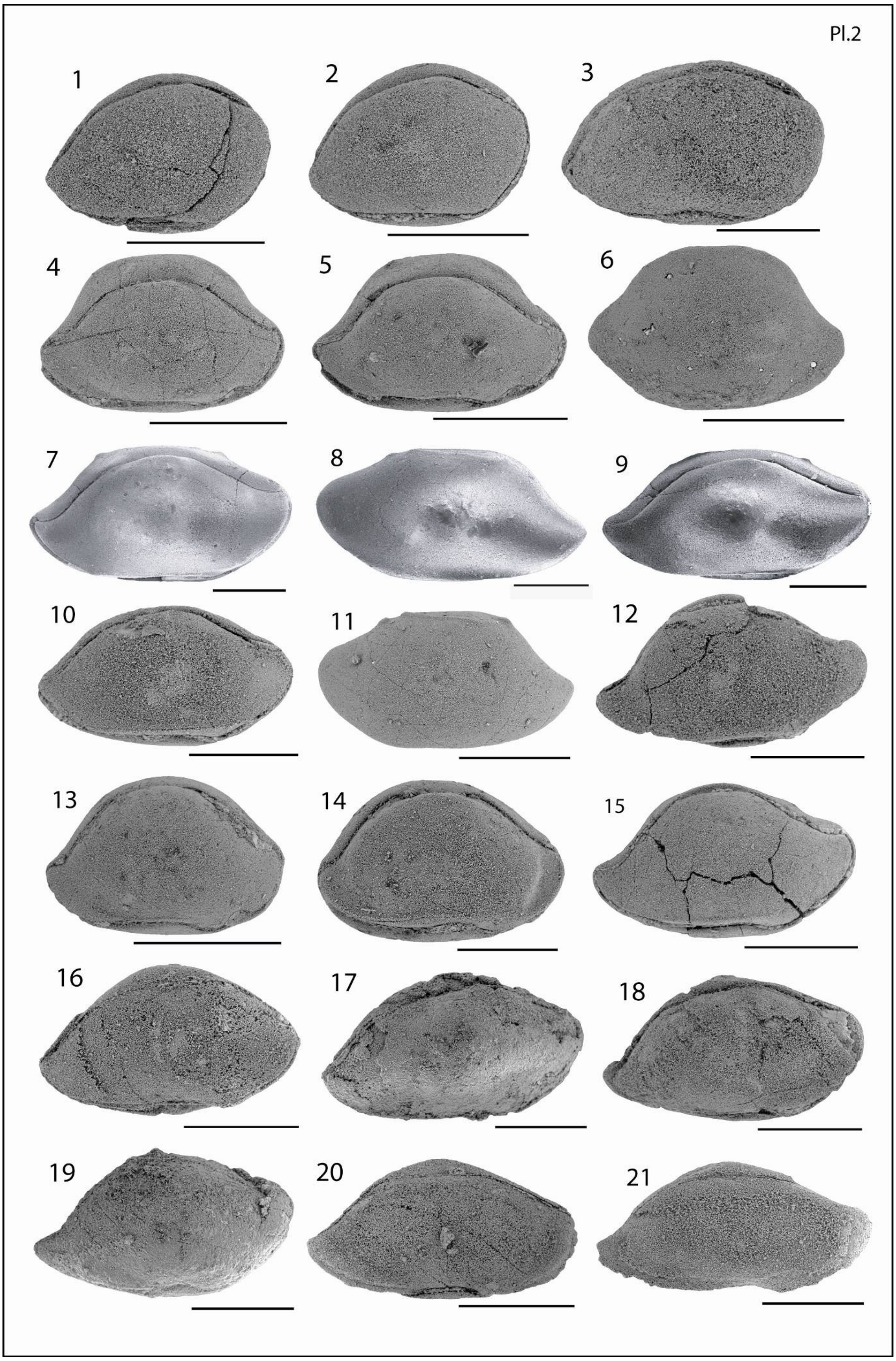
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Plate 3

(Scale bar is 500 µm except for 3-5, 10, 13, 17-20 where it is 300 µm)

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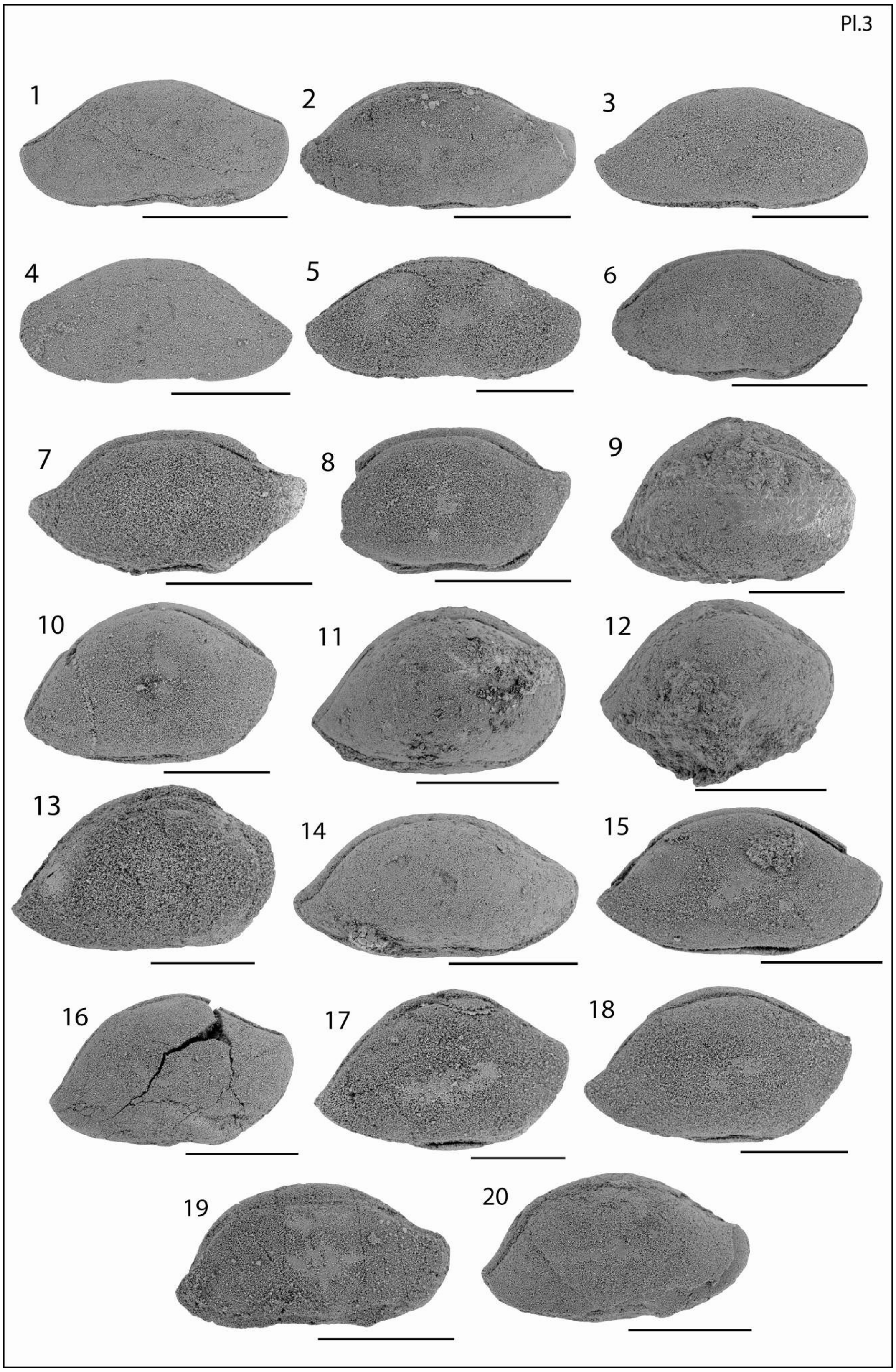
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Plate 4

(Scale bar is 300 µm except for 9-10, 12-13, 17-18, 22 where it is 500 µm, and for 1, 20 where it is 200 µm)

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Figure 22 *Bairdia* sp.9; right lateral view of the complete carapace, SUT-09-1085, sample 07PB03-3.

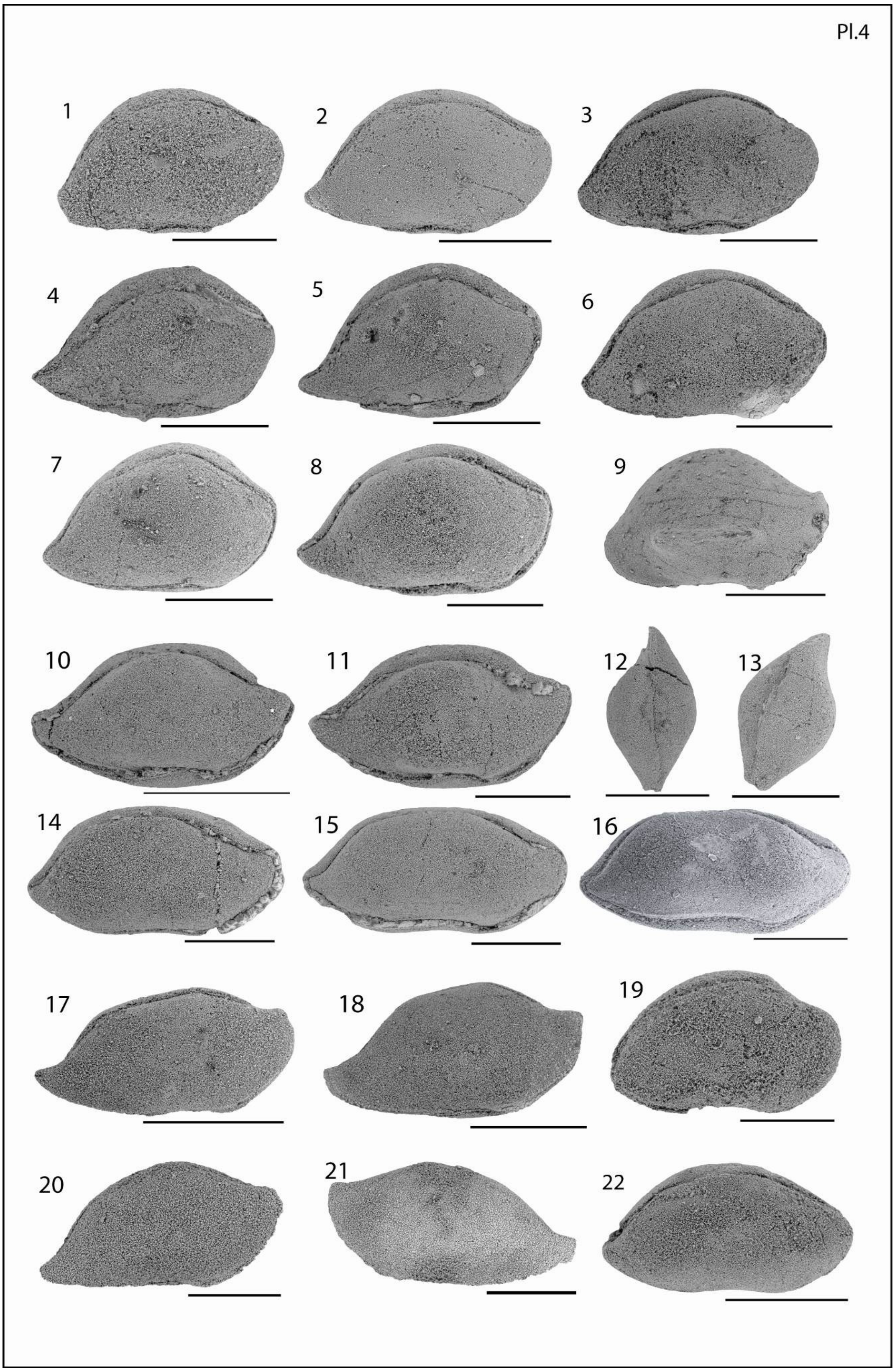
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Plate 5

(Scale bar is500 µm except for 2-3, 7-8, 16-17 where it is 500 µm, and for 6 where it is 200 µm)

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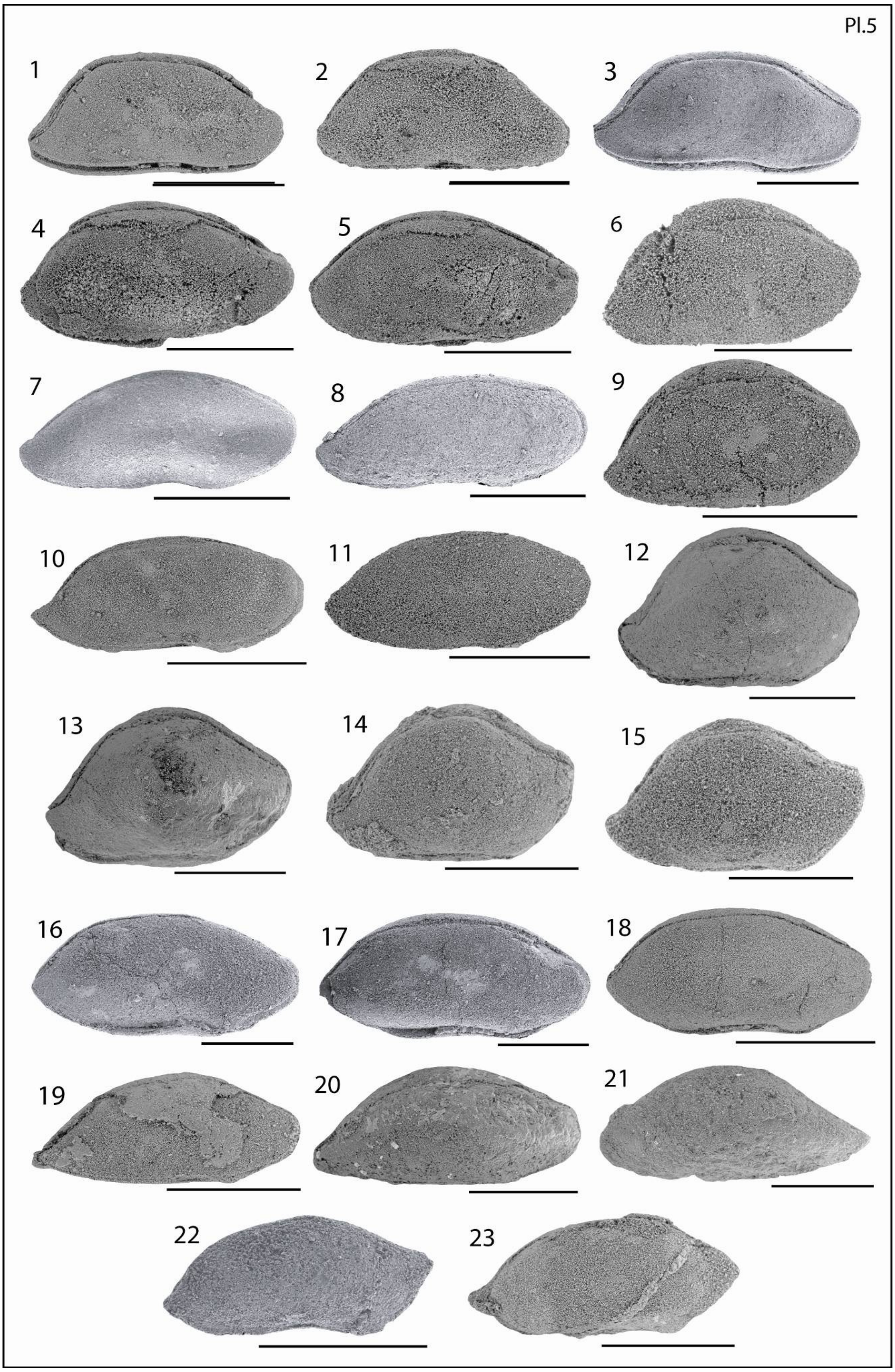
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Plate 6

(Scale bar is 500 µm except for 1-2, 4, 7, 11, 17-20, 22 where it is 500 µm, and for 16 where it is 100 µm)

Figures 1-3 *Bairdia* sp.18; 1 right lateral view of the incomplete carapace, SUT-09-1109, sample 07LB05-6; 2 right lateral view of the incomplete carapace, SUT-09-1110, sample 07LB05-B1; 3 right lateral view of the incomplete carapace, SUT-09-1111, sample 07LB05-B1.

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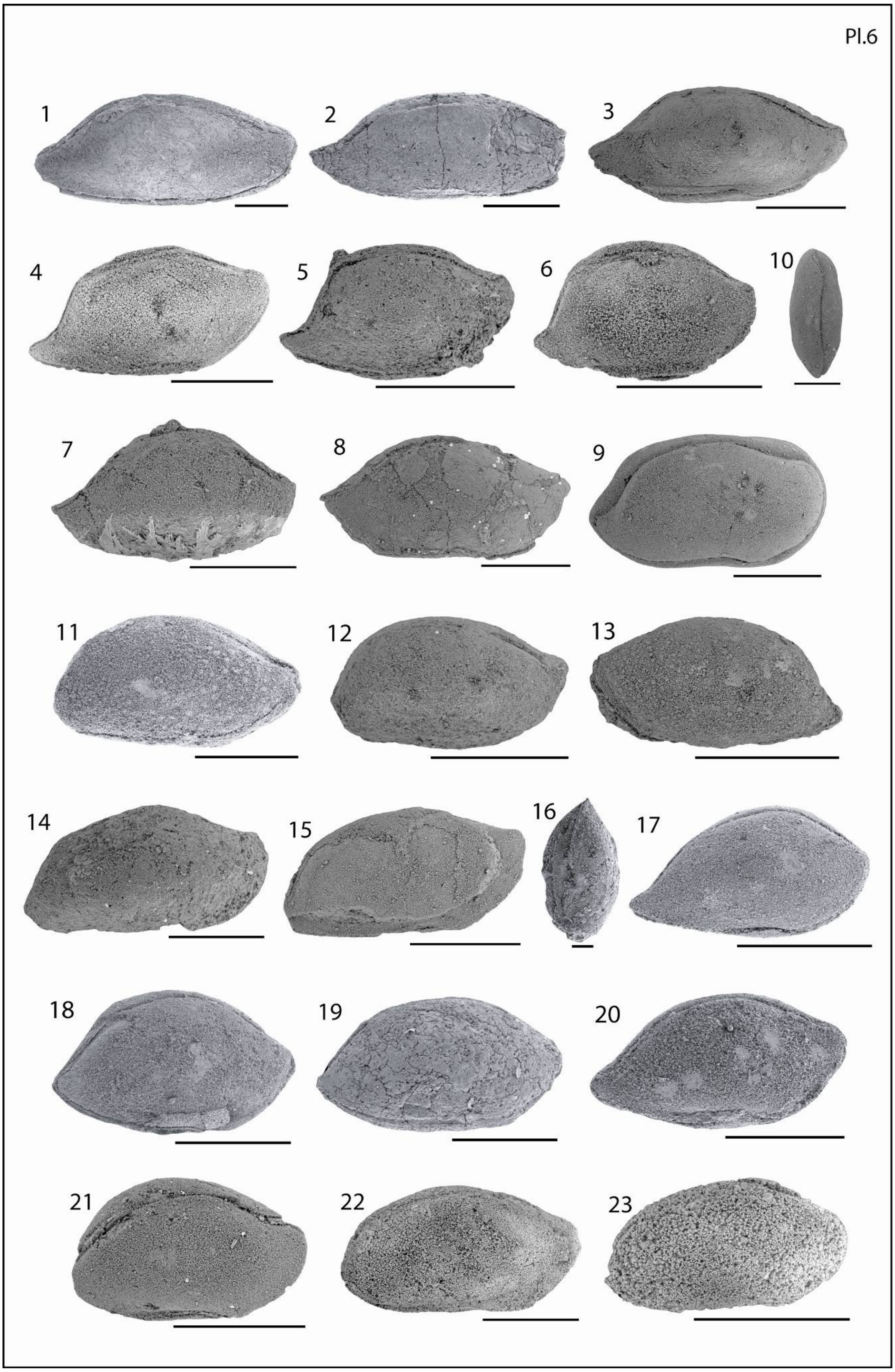
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Plate 7

(Scale bar is 300 µm except for 3-4, 6-7, 11, 17-19 where it is 300 µm)

Figures 1-2 *Bairdia* sp.28; 1 right lateral view of the complete carapace, SUT-09-1132, sample 07LB04-8; 2 right lateral view of the complete carapace, SUT-09-1133, sample 07LB09-2.

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Figures 10-11 *Bairdia* sp.33; 10 right lateral view of the complete carapace, SUT-09-1142, sample 07LB05-C1, scale bar 300 µm; 11 right lateral view of the complete carapace, SUT-09-1143, sample 07LB05-2, scale bar 500 µm.

Figures 13-14 *Bairdia* sp.34; 13 right lateral view of the complete carapace, SUT-09-1144, sample 07LB09-2; 14 right lateral view of the complete carapace, SUT-09-1145, sample 07LB09-1.

Figures 16-19 *Bairdia* sp.35; 16 right lateral view of the complete carapace, SUT-09-1146, sample 07PB04-2; 17 right lateral view of the complete carapace, SUT-09-1147, sample 08LO07-1; 18 right lateral view of the complete carapace, SUT-09-1148, sample 08LO02-11; 19 right lateral view of the complete carapace, SUT-09-1149, sample 08LO02-11.

Figures 20-21 *Bairdia* sp.36; 20 right lateral view of the complete carapace, SUT-09-1151, sample 08LO02-1; 21 right lateral view of the incomplete carapace, SUT-09-1152, sample 08LO02-9.

Figures 22-23 *Bairdia* sp.37; 22 right lateral view of the complete carapace, SUT-09-1153, sample 08LO02-10; 23 right lateral view of the incomplete carapace, SUT-09-1154, sample 08LO02-11.

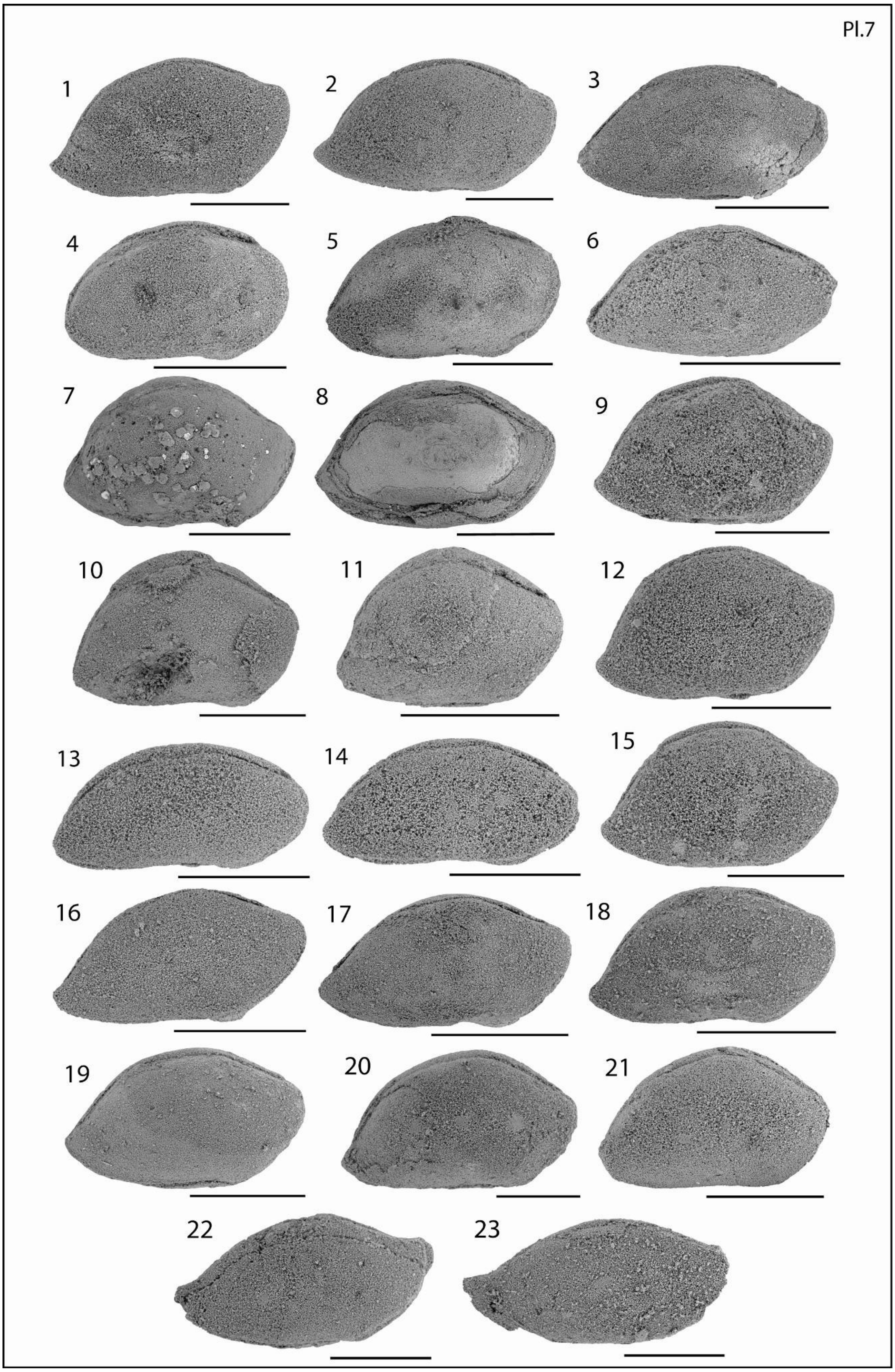
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Plate 8

(Scale bar is300 µm except for 1-2, 6-7, 5-10, 15, 24 where it is 500 µm)

Figures 1-2 *Bairdia* sp.38; 1 right lateral view of the complete carapace, SUT-09-1155, sample 08LO02-10; 2 right lateral view of the incomplete carapace, SUT-09-1156, sample 08LO02-11.

Figures 3, 6, 9 *Bairdia* sp.39; 3 right lateral view of the incomplete carapace, SUT-09-1157, sample 08LO02-2; 6 right lateral view of the incomplete carapace, SUT-09-1158, sample 08LO02-2; 9 right lateral view of the complete carapace, SUT-09-1159, sample 08LO02-10.

Figures 4-5 *Bairdia* sp.40; 4 right lateral view of the incomplete carapace, SUT-09-1160, sample 08LO07-7; 5 right lateral view of the incomplete carapace, SUT-09-1161, sample 08LO07-1.

Figures 7-8 *Bairdia* sp.41; 7 right lateral view of the incomplete carapace, SUT-09-1162, sample 08LO07-8; 8 right lateral view of the incomplete carapace, SUT-09-1163, sample 08LO07-7.

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Figure 12 *Bairdia* sp.47; right lateral view of the complete carapace, SUT-09-1175, sample 07LB04-13.

Figures 13-15 *Bairdia* sp.43; 13 right lateral view of the complete carapace, SUT-09-1166, sample 07LB09-1; 14 right lateral view of the complete carapace, SUT-09-1167, sample 07LB09-2; 15 right lateral view of the incomplete carapace, SUT-09-1168, sample 08LO02-1.

Figures 16-17 *Bairdia* sp.44; 16 right lateral view of the incomplete carapace, SUT-09-1169, sample 08LO07-8; 17 right lateral view of the complete carapace, SUT-09-1170, sample 08PB01.

Figure 18 *Bairdia* sp.48; right lateral view of the complete carapace, SUT-09-1176, sample 08LB01-1.

Figures 19-20 *Bairdia* sp.45; 19 right lateral view of the complete carapace, SUT-09-1171, sample 07LB05-6; 20 right lateral view of the complete carapace, SUT-09-1172, sample 07LB05-3.

Figure 21 *Bairdia* sp.49; right lateral view of the incomplete carapace, SUT-09-1177, sample 08LO07-10.

Figures 22-23 *Bairdia* sp.46; 22 right lateral view of the complete carapace, SUT-09-1173, sample 08LB01-1; 23 right lateral view of the complete carapace, SUT-09-1174, sample 08LB01-1.

Figure 24 *Bairdia* sp.50; right lateral view of the complete carapace, SUT-09-1178, sample 07LB09-2.

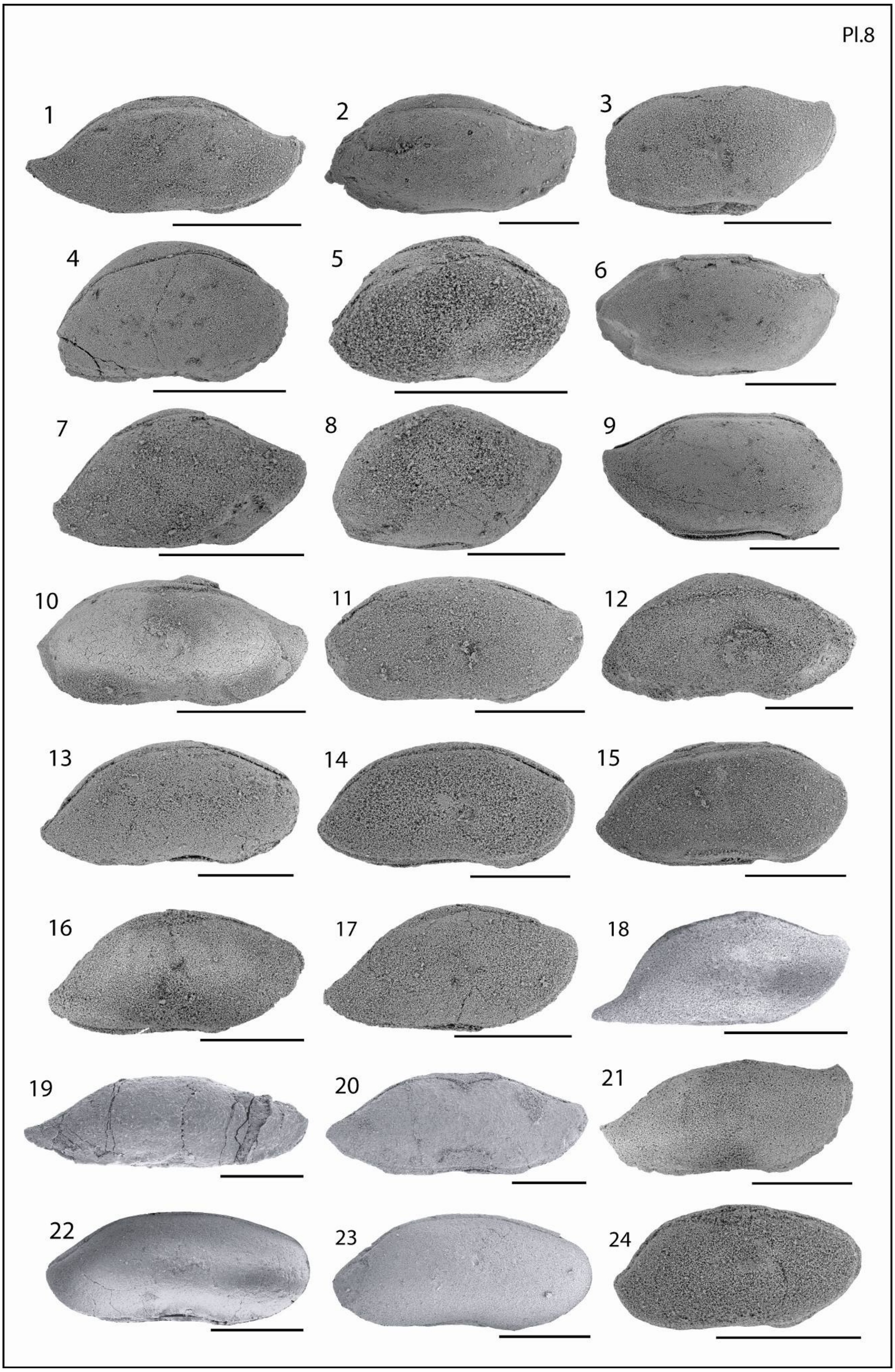
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Plate 9

(Scale bar is 300 µm except for 2-4, 6, 9-11, 16, 18-22, 24 where it is 500 µm)

Figure 1 *Bairdia* sp.51; right lateral view of the incomplete carapace, SUT-09-1179, sample 07LB09-2.

Figure 2 *Bairdia* sp.52; right lateral view of the incomplete carapace, SUT-09-1180, sample 07LB04-13.

Figure 3 *Bairdia* sp.53; right lateral view of the incomplete carapace, SUT-09-1181, sample 08LO02-1.

Figure 4 *Bairdia* sp.54; right lateral view of the incomplete carapace, SUT-09-1182, sample 08LO07-7.

Figure 5 *Bairdia* sp.55; right lateral view of the complete carapace, SUT-09-1183, sample 07PB08-2.

Figures 6, 9 *Bairdia* sp.56; 6 right lateral view of the complete carapace, SUT-09-1184, sample 07LB05-D3; 9 right lateral view of the complete carapace, SUT-09-1185, sample 07LB05-D2.

Figure 7 *Bairdia* sp.57; right lateral view of the complete carapace, SUT-09-1186, sample 07LB05-C1.

Figure 8 *Bairdia* sp.58; right lateral view of the complete carapace, SUT-09-1187, sample 07LB05-B3.

Figures 10-11 *Bairdia* sp.59; 10 right lateral view of the complete carapace, SUT-09-1188, sample 08LO07-1; 11 right lateral view of the incomplete carapace, SUT-09-1189, sample 08LO07-10.

Figures 12, 18 *Bairdia* sp.60; 12 right lateral view of the incomplete carapace, SUT-09-1190, sample 08LB01-1; 18 right lateral view of the incomplete carapace, SUT-09-1191, sample 08LB01-1.

Figures 13-15 *Bairdia* sp.61; 13 right lateral view of the complete carapace, SUT-09-1192, sample 07PB04-2; 14 right lateral view of the complete carapace, SUT-09-1193, sample 07PB04-2; 15 right lateral view of the complete carapace, SUT-09-1194, sample 07LB05-B2.

Figures 16-17 *Bairdia* sp.62; 16 right lateral view of the complete carapace, SUT-09-1195, sample 07LB05-2; 17 left lateral view of the complete carapace, SUT-09-1196, sample 07LB05-3.

Figures 19-20 *Bairdia* sp.63; 19 right lateral view of the incomplete carapace, SUT-09-1197, sample 07PB04-2; 20 left lateral view of the incomplete carapace, SUT-09-1198, sample 07PB04-2.

Figure 21 *Petasobairdia* sp.1; left lateral view of the incomplete carapace, SUT-09-1199, sample 07PB08-3.

Figure 22 *Petasobairdia* sp.2; right lateral view of the incomplete carapace, SUT-09-1200, sample 08LB01-6.

Figure 23 *Petasobairdia* sp.?; right lateral view of the incomplete carapace, SUT-09-1201, sample 08LO01-3.

Figure 24 *Pustulobairdia*? sp.; left lateral view of the incomplete carapace, SUT-09-1202, sample 07PB06-5.

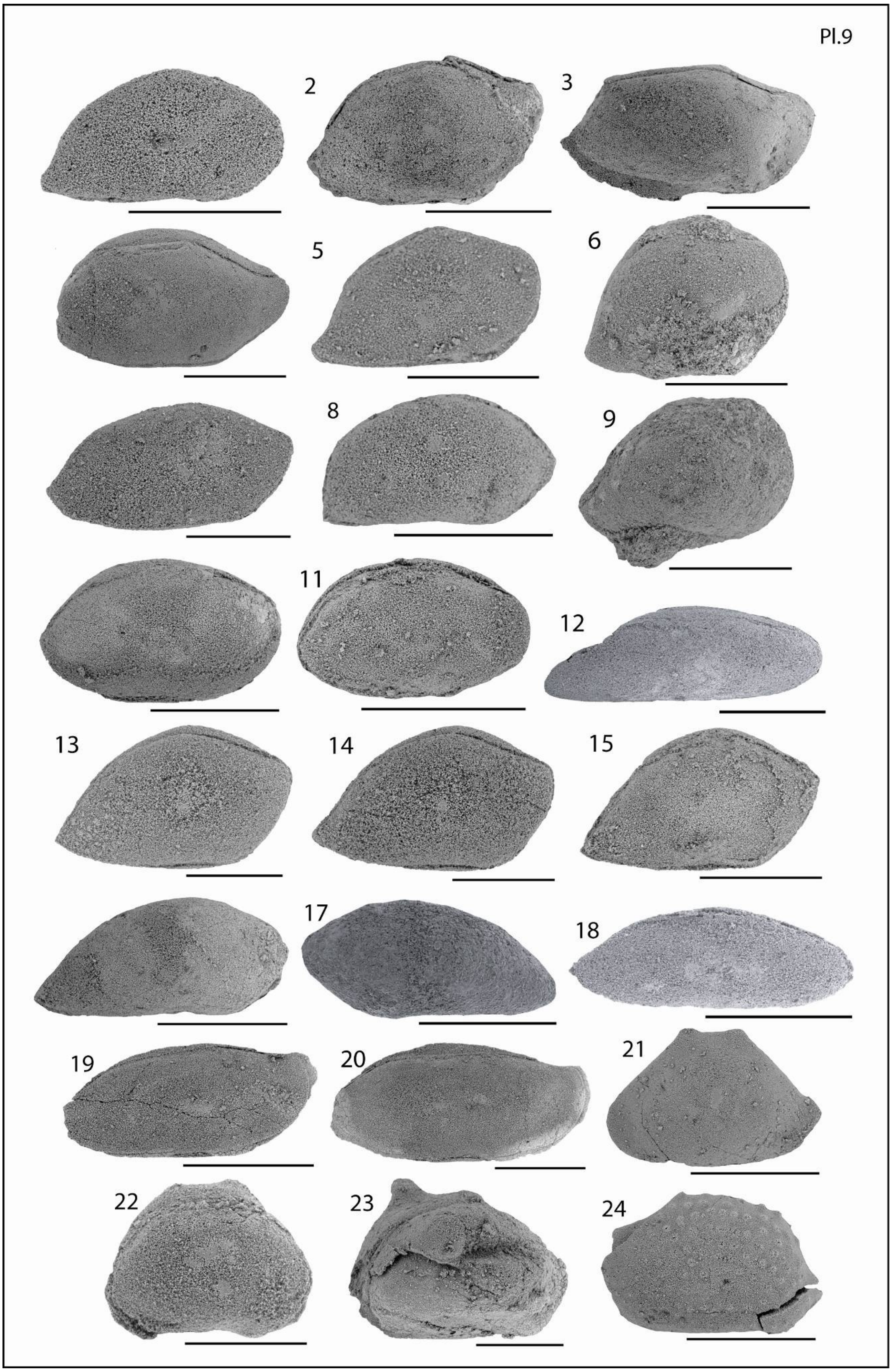
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Plate 10

(Scale bar is 500 µm except for 5, 7-9, 12-13, 16, 18-19, 22 where it is 300 µm)

Figure 1 *Kempfina quinglaii* (Crasquin) 2008; right lateral view of the incomplete carapace, SUT-09-1203, sample 07PB03-7.

Figure 2 *Kempfina* sp.1; right lateral view of the complete carapace, SUT-09-1204, sample 08LB01-2.

Figure 3 *Kempfina* sp.2; right lateral view of the incomplete carapace, SUT-09-1205, sample 08LB01-4.

Figures 4-5 *Bairdiacypris* sp.1; 4 right lateral view of the incomplete carapace, SUT-09-1206, sample 07LB05-B1; 5 right lateral view of the complete carapace, SUT-09-1207, sample 07LB05-2.

Figure 6 *Bairdiacypris longirobusta* Chen, 1958; right lateral view of the incomplete carapace, SUT-09-1211, sample 07LB05-5.

Figures 7-9 *Bairdiacypris* sp.2; 7 right lateral view of the incomplete carapace, SUT-09-1208, sample 08LB01-1; 8 right lateral view of the incomplete carapace, SUT-09-1209, sample 08LB01-1; 9 right lateral view of the incomplete carapace, SUT-09-1210, sample 07LB05-3.

Figures 10-11 *Bairdiacypris* sp.3; 10 right lateral view of the complete carapace, SUT-09-1212, sample 07PB04-2; 11 right lateral view of the complete carapace, SUT-09-1213, sample 07PB04-2.

Figure 12 *Bairdiacypris* sp.7; right lateral view of the complete carapace, SUT-09-1226, sample 07PB03-1.

Figures 13-18 *Bairdiacypris* sp.4; 13 right lateral view of the broken complete carapace, SUT-09-1214, sample 08LO07-8; 14 right lateral view of the complete carapace, SUT-09-1215, sample 07PB04-2; 15 right lateral view of the complete carapace, SUT-09-1216, sample 07PB04-2; 16 right lateral view of the complete carapace, SUT-09-1217, sample 07PB04-2, scale bar 300 µm; 17 right lateral view of the complete carapace, SUT-09-1218, sample 07PB04-2; 18 right lateral view of the complete carapace, SUT-09-1219, sample 08LO07-8.

Figures 19-22 *Bairdiacypris* sp.5; 19 right lateral view of the complete carapace, SUT-09-1220, sample 08LB01-2; 20 right lateral view of the incomplete carapace, SUT-09-1221, sample 08LB01-2; 21 right lateral view of the incomplete carapace, SUT-09-1222, sample 08LB01-3, scale bar 500 µm; 22 right lateral view of the complete carapace, SUT-09-1223, sample 07LB05-C1.

Figures 23-24 *Bairdiacypris* sp.6; 23 right lateral view of the incomplete carapace, SUT-09-1224, sample 08PB05-3; 24 right lateral view of the complete carapace, SUT-09-1225, sample 08LO07-8.


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Plate 11

(Scale bar is300 µm except for 1, 3, 6-8, 15 where it is500 µm)

Figure 1 *Bairdiacypris* sp.7; right lateral view of the incomplete carapace, SUT-09-1227, sample 07PB05-6.

Figures 2-3 *Bairdiacypris* sp.8; 2 right lateral view of the incomplete carapace, SUT-09-1227, sample 07LB05-2; 3 right lateral view of the incomplete carapace, SUT-09-1229, sample 07LB05-2.

Figures 4-6, 9 *Fabalicypris* sp.1; 4 right lateral view of the complete carapace, SUT-09-1230, sample 07PB04-2; 5 right lateral view of the complete carapace, SUT-09-1231, sample 07PB04-2; 6 right lateral view of the complete carapace, SUT-09-1232, sample 07PB04-2; 9 left lateral view of the complete carapace, SUT-09-1233, sample 07PB04-2.

Figures 7-8 *Fabalicypris* sp.2; 7 right lateral view of the incomplete carapace, SUT-09-1234, sample 07LB05-A3; 8 right lateral view of the complete carapace, SUT-09-1235, sample 07LB05-A3.

Figures 10-12 *Fabalicypris* sp.3; 10 right lateral view of the incomplete carapace, SUT-09-1236, sample 08LO01-4; 11 right lateral view of the incomplete carapace, SUT-09-1237, sample 08LO01-4; 12 right lateral view of the incomplete carapace, SUT-09-1238, sample 07LB05-A3.

Figure 13 *Fabalicypris* sp.4; right lateral view of the complete carapace, SUT-09-1239, sample 07LB04-17.

Figure 14 Bairdiidae sp.; right lateral view of the complete carapace, SUT-09-1243, sample 08LO02-1.

Figure 15 *Bairdia* sp.?; right lateral view of the incomplete carapace, SUT-09-1247, sample 08LB01-6.

Figures 16-18 *Baschkirina* sp.1; 16 right lateral view of the complete carapace, SUT-09-1240, sample 07LB09-2; 17 right lateral view of the complete carapace, SUT-09-1241, sample 07LB09-2; 18 left lateral view of the complete carapace, SUT-09-1242, sample 07LB09-2.

Figures 19-21 *Baschkirina* sp.2; 19 left lateral view of the complete carapace, SUT-09-1244, sample 08LB01-1; 20 right lateral view of the complete carapace, SUT-09-1245, sample 08LB01-1; 21 right lateral view of the complete carapace, SUT-09-1246, sample 08LB01-1.

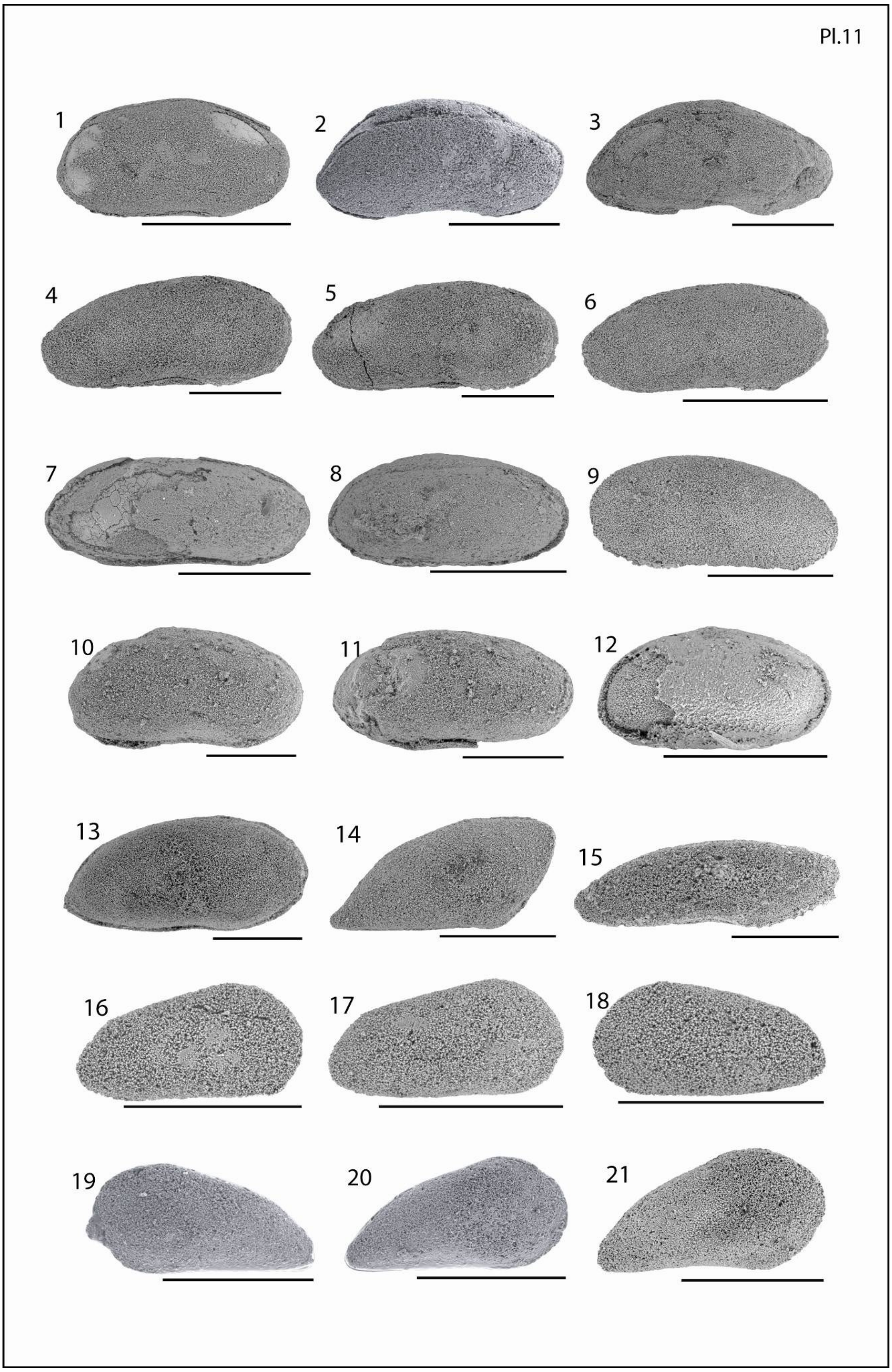
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Plate 12

(Scale bar is 300 µm except for 6 where it is 500 µm, for 7-9, 11-12 where it is 200 µm)

Figures 1-2, 4-5 *Baschkirina* sp.3; 1 right lateral view of the complete carapace, SUT-09-1248, sample 07PB04-5; 2 right lateral view of the complete carapace, SUT-09-1249, sample 07PB04-5; 4 right lateral view of the complete carapace, SUT-09-1250, sample 08LO02-2; 5 right lateral view of the complete carapace, SUT-09-1251, sample 08LO02-2.

Figure 3 *Bogerscottia* sp.?; right lateral view of the incomplete carapace, SUT-09-1252, sample 08LO05-7.

Figure 6 *Paramacrocypris* sp.; right lateral view of the complete carapace, SUT-09-1262, sample 08LB01-4.

Figures 7-15 *Baschkirina* sp.4; 7 left lateral view of the complete carapace, SUT-09-1253, sample 07LB04-8; 8 left lateral view of the complete carapace, SUT-09-1254, sample 07LB04-8; 9 left lateral view of the complete carapace, SUT-09-1255, sample 07PB03-3; 10 right lateral view of the complete carapace, SUT-09-1256, sample 07PB04-5; 11 left lateral view of the complete carapace, SUT-09-1257, sample 07PB03-3; 12 left lateral view of the complete carapace, SUT-09-1258, sample 07PB03-3; 13 right lateral view of the complete carapace, SUT-09-1259, sample 08LO02-1; 14 right lateral view of the complete carapace, SUT-09-1260, sample 08LO02-2; 15 left lateral view of the complete carapace, SUT-09-1261, sample 08LO02-2.

Figures 16-19 *Baschkirina* sp.5; 16 right lateral view of the complete carapace, SUT-09-1262, sample 07LB09-1; 17 right lateral view of the complete carapace, SUT-09-

1263, sample 07LB09-1; 18 right lateral view of the complete carapace, SUT-09-1264, sample 07LB09-2; 19 left lateral view of the complete carapace, SUT-09-1265, sample 07LB09-2.

Figures 20-21 *Cytherellina* sp.; 20 right lateral view of the complete carapace, SUT-09-1266, sample 07LB04-17; 21 right lateral view of the complete carapace, SUT-09-1267, sample 07LB04-17.

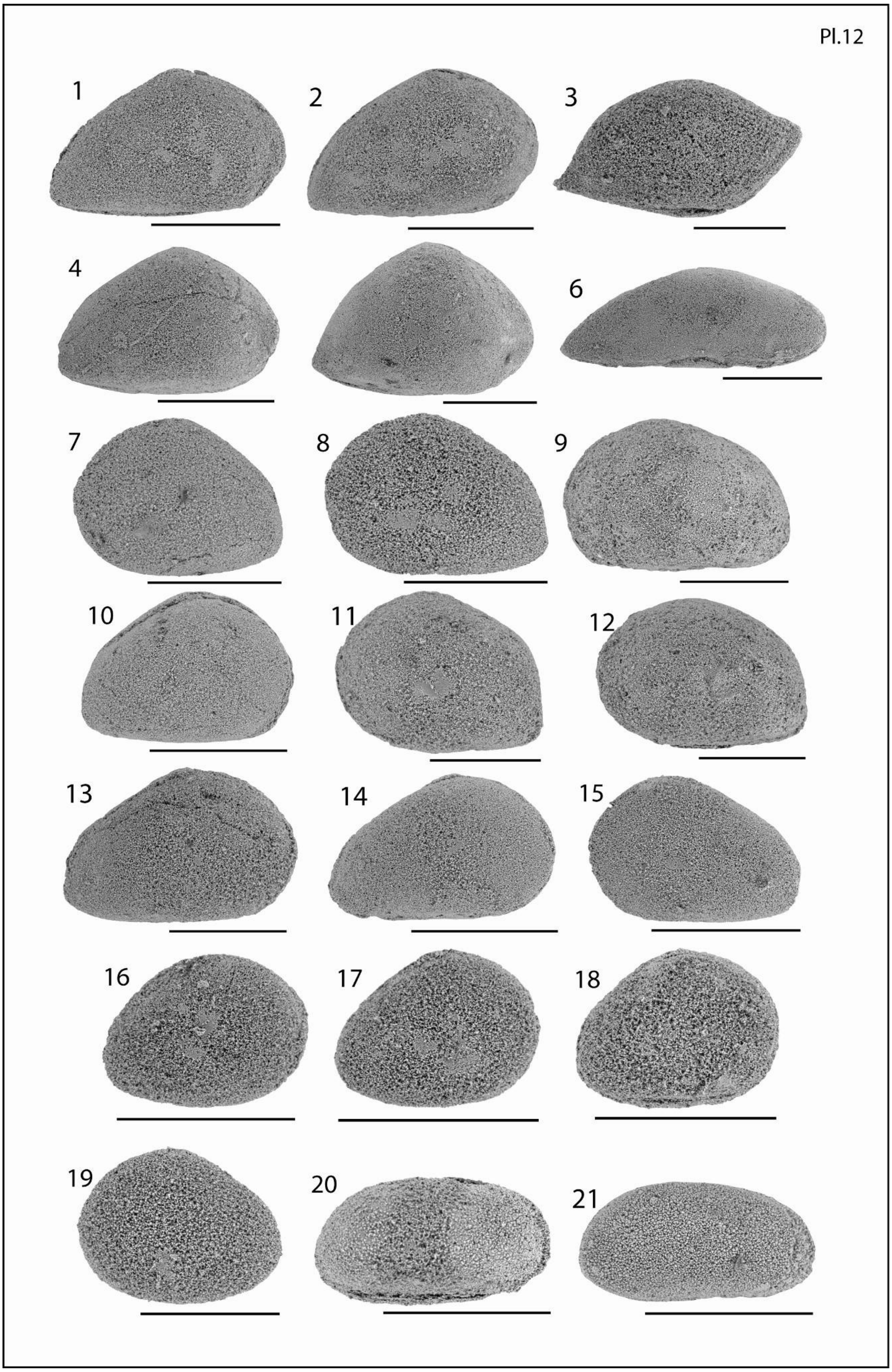
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Plate 13

(Scale bar is 300 μm except for 15-18 where it is 500 μm)

Figures 1-3 *Liuzhinia* sp.1; 1 right lateral view of the complete carapace, SUT-09-1268, sample 07LB09-1; 2 right lateral view of the complete carapace, SUT-09-1269, sample 07PB03-5; 3 right lateral view of the complete carapace, SUT-09-1270, sample 07LB09-1.

Figures 4-5 *Liuzhinia* sp.2; 4 right lateral view of the complete carapace, SUT-09-1271, sample 08LO02-5; 5 right lateral view of the complete carapace, SUT-09-1272, sample 08LO02-5.

Figures 6, 9 *Liuzhinia* sp.4; 6 right lateral view of the incomplete carapace, SUT-09-1275, sample 07LB04-13; 9 right lateral view of the complete carapace, SUT-09-1276, sample 07LB04-13.

Figures 7-8 *Liuzhinia* sp.3; 7 right lateral view of the complete carapace, SUT-09-1273, sample 07LB09-2; 8 right lateral view of the complete carapace, SUT-09-1274, sample 07LB09-1.

Figures 10-24 *Acratia* sp.1; 10 right lateral view of the complete carapace, SUT-09-1276, sample 07LB05-6; 11 right lateral view of the complete carapace, SUT-09-1277, sample 07PB03-2; 12 left lateral view of the complete carapace, SUT-09-1278, sample 07PB03-2; 13 ventral view of the complete carapace, SUT-09-1279, sample 07PB03-2; 14 dorsal view of the complete carapace, SUT-09-1284, sample 07PB03-5; 15 right lateral view of the complete carapace, SUT-09-1280, sample 07PB03-5; 16 right lateral view of the complete carapace, SUT-09-1281, sample 07PB03-5; 17 right lateral view of the complete carapace, SUT-09-1282, sample 07PB0-5; 18 right lateral view of the complete carapace, SUT-09-1283, sample 07PB03-3; 19 right lateral view of the complete carapace, SUT-09-1285, sample 07PB03-5; 20 right lateral view of the complete carapace, SUT-09-1286, sample 07PB03-3; 21 left lateral view of the complete carapace, SUT-09-1287, sample 07PB03-5; 22 left lateral view of the complete carapace, SUT-09-1288, sample 07PB03-3; 23 right lateral view of the complete carapace, SUT-09-1289, sample 07PB03-5; 24 right lateral view of the complete carapace, SUT-09-1290, sample 07PB03-3.

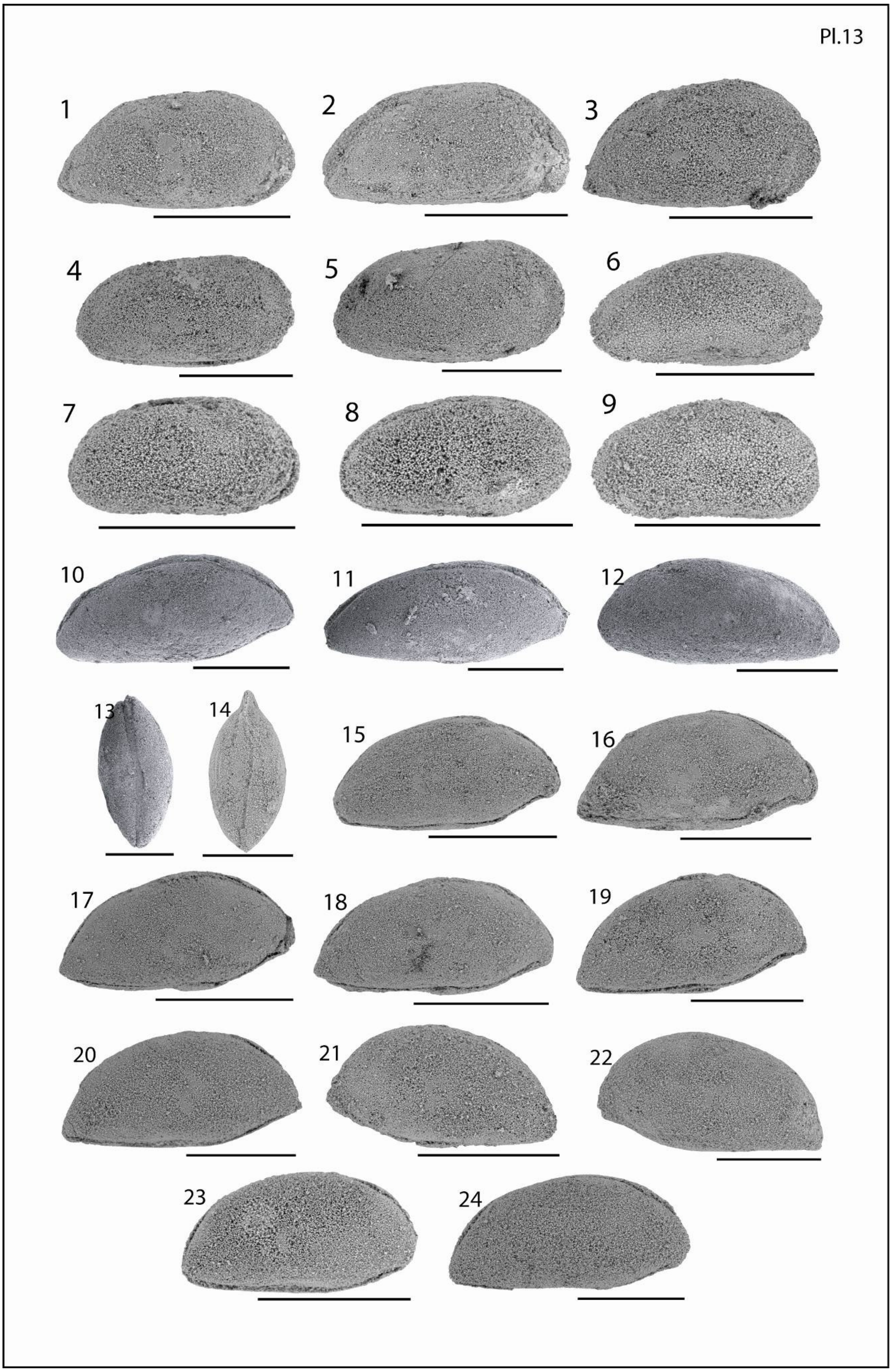
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Plate 14

(Scale bar is 300 μm except for 2-3, 12-13, 15 where it is 500 μm)

Figures 1-2 *Acratia* sp.2; 1 right lateral view of the complete carapace, SUT-09-1290, sample 08LB01-3; 2 left lateral view of the complete carapace, SUT-09-1291, sample 08LB01-3.

Figures 3-6 *Acratia* sp.3; 3 right lateral view of the incomplete carapace, SUT-09-1292, sample 08PB02-12; 4 right lateral view of the complete carapace, SUT-09-1293, sample 07PB04-22; 5 right lateral view of the complete carapace, SUT-09-1293, sample 07PB04-2; 6 right lateral view of the incomplete carapace, SUT-09-1294, sample 07LB09-1.

Figures 7-8 *Acratia* sp.4; 7 right lateral view of the complete carapace, SUT-09-1295, sample 08LO07-1; 8 right lateral view of the complete carapace, SUT-09-1296, sample 08LB01-1.

Figure 9 *Pseudoacanthoscapha striatula*? (Shi, 1982); right lateral view of the incomplete carapace, SUT-09-1297, sample 08LO07-2.

Figure 10 *Silenites* sp.1; right lateral view of the incomplete carapace, SUT-09-1298, sample 08LB01-6.

Figures 11-14 *Silenites* sp.2; 11 right lateral view of the complete carapace, SUT-09-1299, sample 07PB04-5; 12 right lateral view of the complete carapace, SUT-09-1300, sample 07LB05-D3; 13 right lateral view of the incomplete carapace, SUT-09-1301, sample 07PB08-3; 14 right lateral view of the complete carapace, SUT-09-1302, sample 07LB05-D3, scale bar 300 μm.

Figure 15 *Silenites* sp.3; right lateral view of the incomplete carapace, SUT-09-1303, sample 07PB05-5.

Figures 16-22 *Basslerella* sp.1; 16 right lateral view of the complete carapace, SUT-09-1304, sample 07PB03-5; 17 right lateral view of the complete carapace, SUT-09-1305, sample 07PB04-2; 18 right lateral view of the complete carapace, SUT-09-1306, sample 07PB03-5,; 19 left lateral view of the complete carapace, SUT-09-1307, sample 07PB03-5; 20 right lateral view of the complete carapace, SUT-09-1308, sample 07PB03-5; 21 left lateral view of the complete carapace, SUT-09-1309, sample 07LB09-1; 22 ventral view of the complete carapace, SUT-09-1310, sample 07LB09-2.

Figures 23-25 *Basslerella* sp.2; 23 right lateral view of the complete carapace, SUT-09-1311, sample 08LO02-2; 24 right lateral view of the complete carapace, SUT-09-1312,, sample 08LO02-2; 25 ventral view of the complete carapace, SUT-09-1313, sample 08LO02-2.

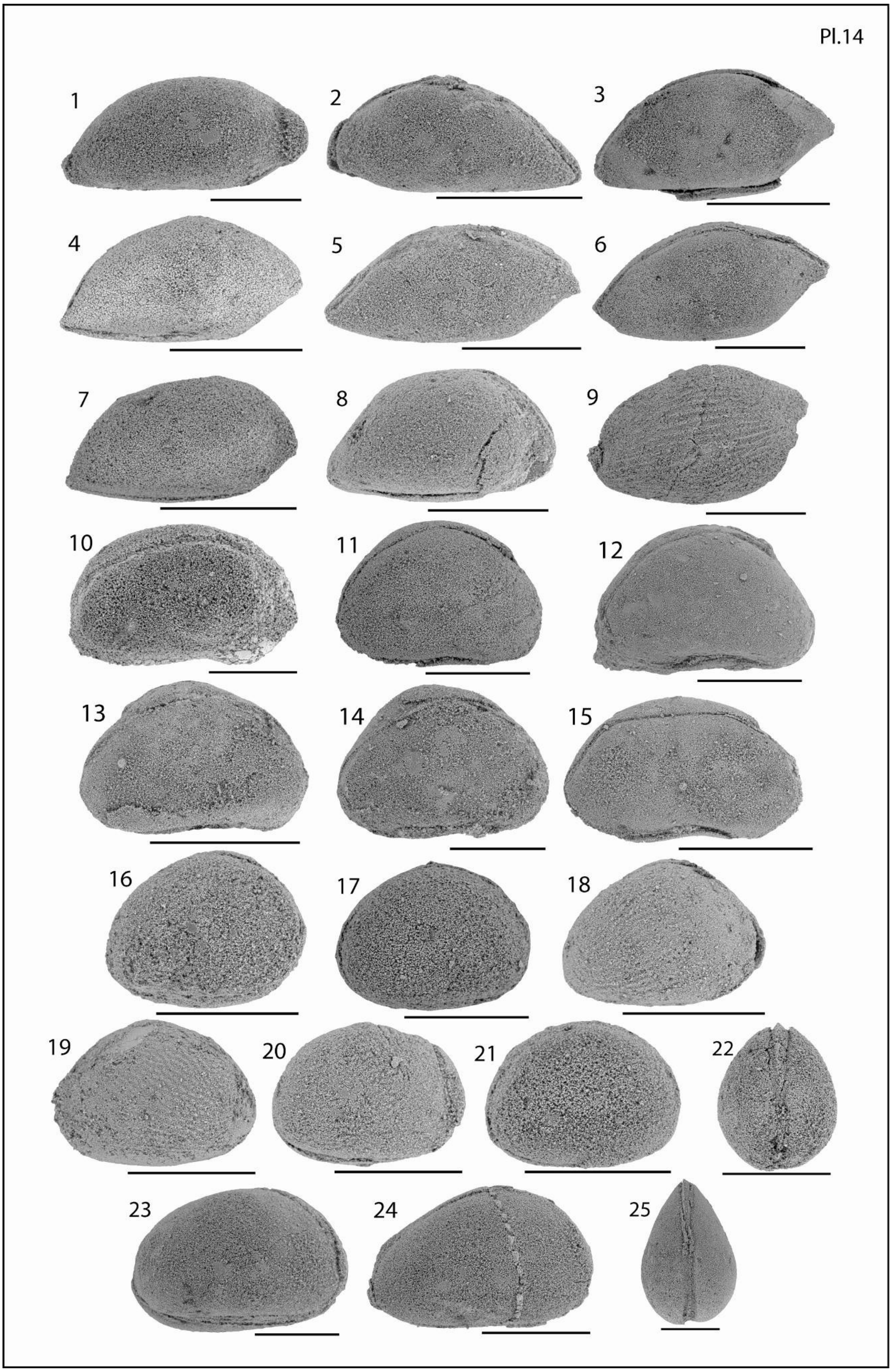
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Plate 15

(Scale bar is 300 µm except for 12 where it is 500 µm)

Figures 1-4 *Cavellina* sp.1; 1 right lateral view of the complete carapace, SUT-09-1314, sample 07PB03-3; 2 right lateral view of the complete carapace, SUT-09-1315, sample 07PB03-3; 3 right lateral view of the complete carapace of the complete carapace, SUT-09-1316, sample 07PB03-3; 4 right lateral view of the complete carapace, SUT-09-1317, sample 07LB05-A2.

Figures 5-8 *Sulcella suprapermiana* Kozur, 1985; 5 right lateral view of the complete carapace, SUT-09-1318, sample 08LB01-1; 6 right lateral view of the complete carapace, SUT-09-1319, sample 08LB01-1; 7 right lateral view of the complete carapace, SUT-09-1320, sample 07PB03-1; 8 right lateral view of the complete carapace, SUT-09-1321, sample 07LB04-17.

Figures 9-11 *Sulcella mesopermiana* Kozur, 1985; 9 right lateral view of the complete carapace, SUT-09-1322, sample 07PB03-1; 10 right lateral view of the complete carapace, SUT-09-1323, sample 07PB03-3; 11 right lateral view of the complete carapace, SUT-09-1324, sample 07PB03-3.

Figure 12 *Microcheilinella* sp.4; right lateral view of the complete carapace, SUT-09-1334, sample 07PB08-3.

Figures 13-14 *Microcheilinella venusta* Chen, 1958; 13 right lateral view of the complete carapace, SUT-09-1325, sample 07LB05-B1; 14 dorsal view of the complete carapace, SUT-09-1326, sample 07LB05-B1.

Figures 15-16 *Microcheilinella* sp.1; 15 right lateral view of the complete carapace, SUT-09-1327, sample 07LB05-B2; 16 ventral view of the complete carapace, SUT-09-1328, sample 07LB05-B2.

Figures 17-20 *Microcheilinella* sp.2; 17 right lateral view of the complete carapace, SUT-09-1329, sample 07PB04-2; 18 right lateral view of the complete carapace, SUT-09-1330, sample 07PB04-2; 19 left lateral view of the complete carapace, SUT-09-1331, sample 07PB04-2; 20 ventral view of the complete carapace, SUT-09-1332, sample 08LO07-1.

Figure 21 *Microcheilinella* sp.3; right lateral view of the complete carapace, SUT-09-1333, sample 07LB05-B2.

Figures 22-24 *Microcheilinella* sp.5; 22 right lateral view of the complete carapace, SUT-09-1335, sample 07LB05-D3; 23 right lateral view of the complete carapace, SUT-09-1336, sample 07LB05-B1; 24 ventral view of the complete carapace, SUT-09-1337, sample 07LB05-D3.

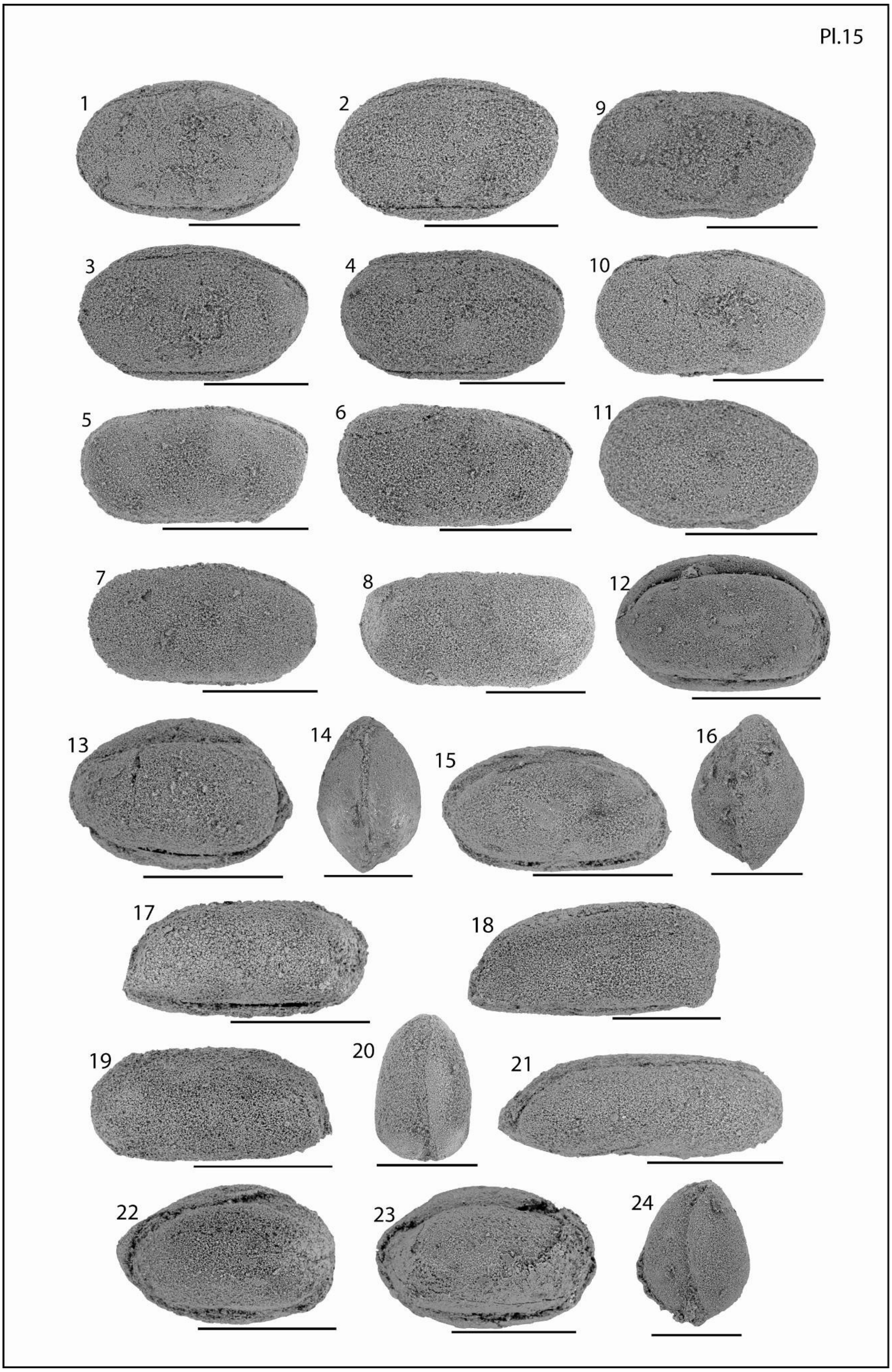
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Plate 16

(Scale bar is 300 µm except for 3 where it is 500 µm, and for 4-5 where it is 200 µm)

Figure 1 *Microcheilinella* sp.6; right lateral view of the incomplete carapace, SUT-09-1338, sample 08LB01-2.

Figure 2 *Microcheilinella* sp.7; right lateral view of the incomplete carapace, SUT-09-1339, sample 07LB05-D2.

Figure 3 *Microcheilinella* sp.8; right lateral view of the incomplete carapace, SUT-09-1340, sample 08KB05-4.

Figures 4-6 *Microcheilinella* sp.9; 4 right lateral view of the complete carapace, SUT-09-1341, sample 07PB05-2; 5 right lateral view of the complete carapace, SUT-09-1342, sample 07PB05-2; 6 dorsal view of the complete carapace, SUT-09-1343, sample 07PB05-2.

Figure 7 *Microcheilinella* sp.10; right lateral view of the complete carapace, SUT-09-1344, sample 08PB02-13.

Figures 8-12 *Cyathus* sp.1; 8 left lateral view of the complete carapace, SUT-09-1345, sample 07PB04-2; 9 left lateral view of the complete carapace, SUT-09-1346, sample 07PB04-2; 10 dorsal view of the complete carapace, SUT-09-1347, sample 07PB04-2; 11 ventral view of the complete carapace, SUT-09-1348, sample 07PB04-2; 12 left lateral view of the complete carapace, SUT-09-1349, sample 07LB05-D2.

Figures 13-16 *Cyathus* sp.2; 13 dorsal view of the complete carapace, SUT-09-1350, sample 07LB05-D2; 14 ventral view of the complete carapace, SUT-09-1351, sample 07LB05-D2; 15 left lateral view of the complete carapace, SUT-09-1352, sample

07PB04-2; 16 left lateral view of the complete carapace, SUT-09-1353, sample 07PB04-5.

Figures 17-19 *Microcoelonella* sp.1; 17 left lateral view of the complete carapace, SUT-09-1354, sample 07LB05-B2; 18 left lateral view of the complete carapace, SUT-09-1355, sample 07LB05-2; 19 dorsal view of the complete carapace, SUT-09-1356, sample 07LB05-2.

Figures 20-25 *Microcoelonella* sp.2; 20 left lateral view of the complete carapace, SUT-09-1357, sample 07LB05-A1; 21 left lateral view of the complete carapace, SUT-09-1358, sample 07LB05-A1; 22 dorsal view of the complete carapace, SUT-09-1359, sample 07LB05-D2; 23 ventral view of the complete carapace, SUT-09-1360, sample 07LB05-D2; 24 right lateral view of the complete carapace, SUT-09-1361, sample 07LB05-D2; 25 left lateral view of the complete carapace, SUT-09-1362, sample 07LB05-D3.

Figures 26-29 *Microcoelonella* sp.?; 26 left lateral view of the complete carapace, SUT-09-1363, sample 07LB05-A1; 27 right lateral view of the complete carapace, SUT-09-1364, sample 07LB05-A1; 28 dorsal view of the complete carapace, SUT-09-1365, sample 07LB05-A1; 29 ventral view of the complete carapace, SUT-09-1366, sample 07LB05-A1.

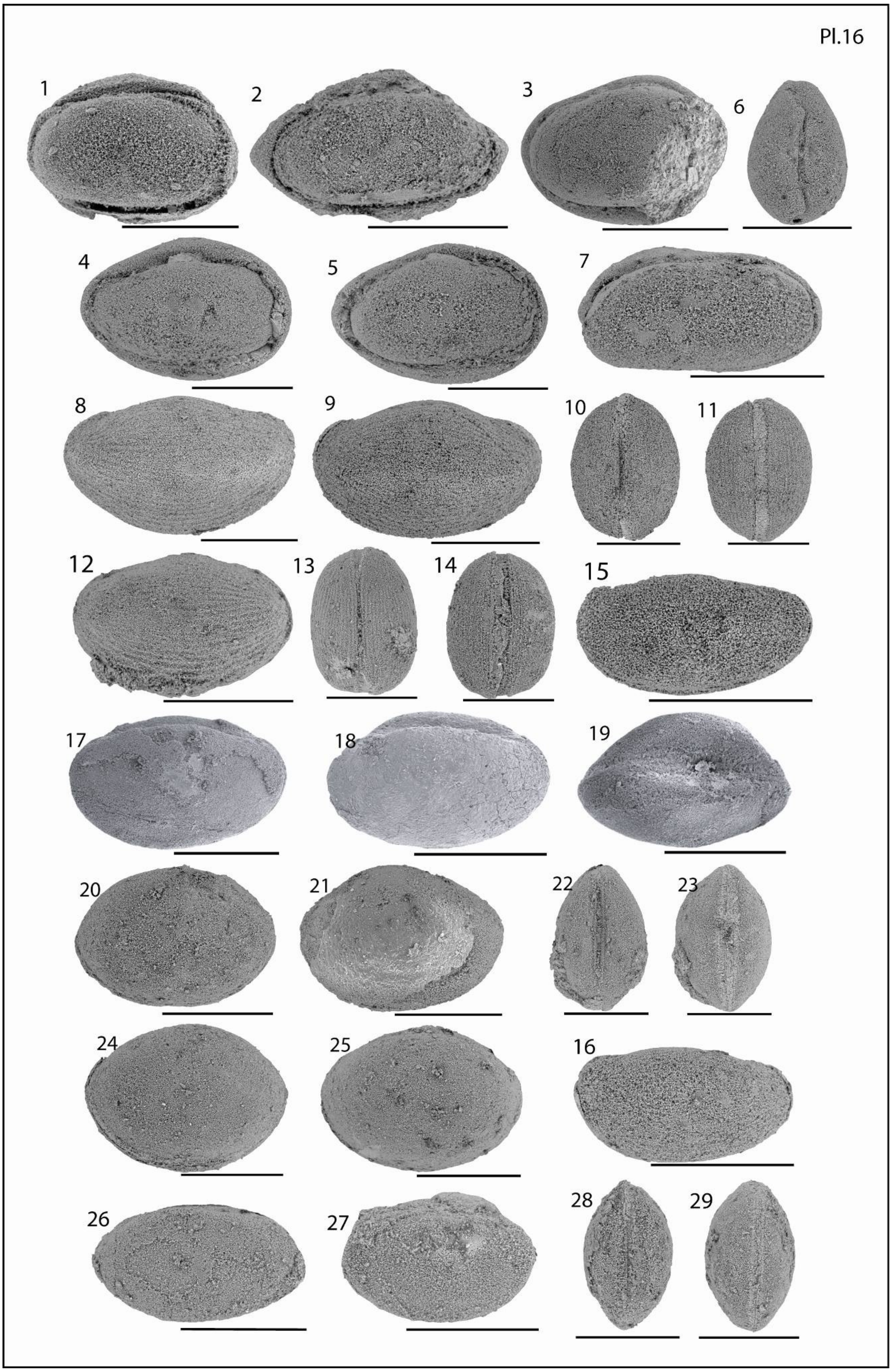
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Plate 17

(Scale bar is 300 µm except for 23 where it is 500 µm)

Figures 1-4 *Polycope* sp.1; 1 left lateral view of the complete carapace, SUT-09-1367, sample 07PB04-2; 2 posterior view of the complete carapace, SUT-09-1368, sample 07PB04-2; 3 left lateral view of the complete carapace, SUT-09-1369, sample 08LO02-2; 4 right lateral view of the complete carapace, SUT-09-1370, sample 07LB05-B2.

Figures 5-7 *Polycope* sp.2; 5 left lateral view of the complete carapace, SUT-09-1371, sample 08LO02-5; 6 right lateral view of the complete carapace, SUT-09-1372, sample 08LO02-5; 7 dorsal view of the complete carapace, SUT-09-1373, sample 08LO02-5.

Figures 8-13 *Polycope* sp.3; 8 left lateral view of the complete carapace, SUT-09-1379, sample 07LB09-1; 9 left lateral view of the complete carapace, SUT-09-1374, sample 07PB04-5; 10 right lateral view of the complete carapace, SUT-09-1375, sample 08LO02-2; 11 left lateral view of the complete carapace, SUT-09-1376, sample 08LO02-2; 12 left lateral view of the complete carapace, SUT-09-1377, sample 07LB09-1; 13 left lateral view of the complete carapace, SUT-09-1378, sample 07LB09-1.

Figures 14-16 *Polycope*? sp.; 14 lateral view of the incomplete carapace, SUT-09-1380, sample 07PB06-5; 15 lateral view of the complete carapace, SUT-09-1381, sample 07PB06-5; 16 lateral view of the complete carapace, SUT-09-1382, sample 07PB06-5.

Figures 17-19 *Samarella* sp.1; 17 right lateral view of the complete carapace, SUT-09-1383, sample 07LB05-2; 18 right lateral view of the complete carapace, SUT-09-1384, sample 07LB09-2; 19 left lateral view, SUT-09-1385, sample 07LB09-2.

Figures 20-27 *Samarella* sp.2; 20 left lateral view of the complete carapace, SUT-09-1386, sample 07LB05-D3; 21 left lateral view of the complete carapace, SUT-09-1387, sample 07LB05-D3; 22 left lateral view of the complete carapace, SUT-09-1388, sample 07LB05-D3; 23 dorsal view of the complete carapace, SUT-09-1389, sample 07LB05-D3; 24 left lateral view of the complete carapace, SUT-09-1390, sample 07LB05-D2; 25 right lateral view of the complete carapace, SUT-09-1391, sample 07LB05-D3; 26 left lateral view of the complete carapace, SUT-09-1392, sample 07LB05-D2; 27 right lateral view of the complete carapace, SUT-09-1393, sample 07LB05-D2.

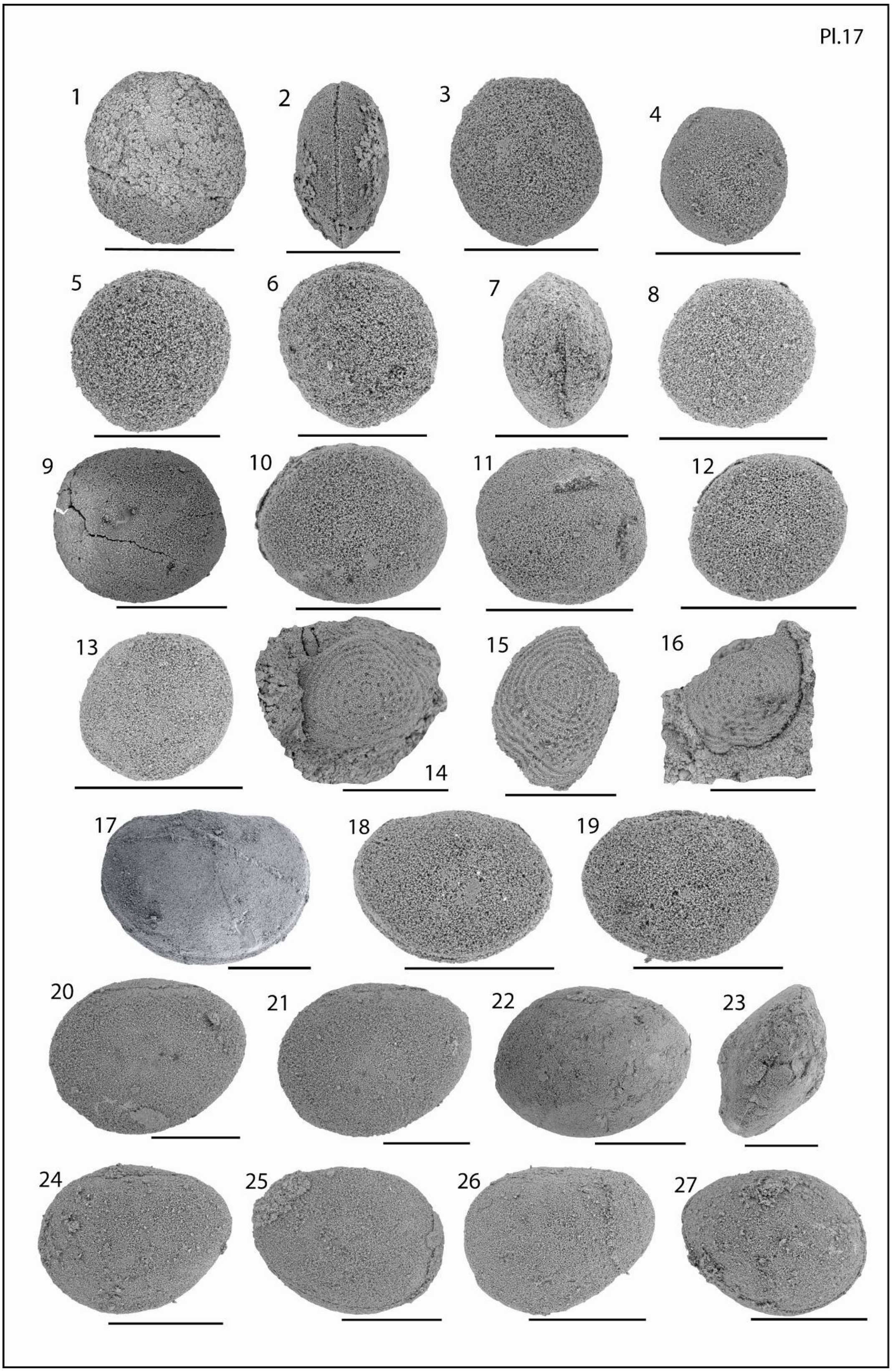
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Plate 18

(Scale bar is 300 µm except for 10, 12, 15-17 where it is 500 µm)

Figures 1-6 *Samarella* sp.3; 1 left lateral view of the complete carapace, SUT-09-1394, sample 07PB04-2; 2 left lateral view of the complete carapace, SUT-09-1395, sample 07PB04-2; 3 right lateral view of the complete carapace, SUT-09-1396, sample 07PB04-5; 4 left lateral view of the complete carapace, SUT-09-1397, sample 07LB05-A1; 5 left lateral view of the complete carapace, SUT-09-1398, sample 07LB05-A1; 6 left lateral view of the complete carapace, SUT-09-1399, sample 07PB04-2.

Figures 7-8 *Samarella* sp.4; 7 left lateral view of the complete carapace, SUT-09-1400, sample 07PB04-2; 8 right lateral view of the complete carapace, SUT-09-1401, sample 07PB04-2.

Figure 9 *Shishaella* sp.; right lateral view of the incomplete carapace, SUT-09-1403, sample 07LB05-D2.

Figures 10-11 *Samarella* sp.5; 10 left lateral view of the incomplete carapace, SUT-09-1402, sample 07LB05-D3; 11 left lateral view of the incomplete carapace, SUT-09-1403, sample 07LB05-D2.

Figure 12 *Shemonaella* sp.1; left lateral view of the complete carapace, SUT-09-1405, sample 08LO02-2.

Figures 13-14 *Shemonaella* sp.2; 13 left lateral view of the complete carapace, SUT-09-1406, sample 07LB05- 2; 14 left lateral view of the complete carapace, SUT-09-1407, sample 07LB05-2.

Figures 15-19 *Paraparchites* sp.1; 15 right lateral view of the complete carapace , SUT-09-1408, sample 08LO02-10; 16 right lateral view of the complete carapace, SUT-09-1409, sample 08LO01-3; 17 left lateral view of the complete carapace, SUT-09-1410, sample 08LO02-1; 18 right lateral view of the complete carapace, SUT-09-1411, sample 07LB05-A1; 19 right lateral view of the complete carapace, SUT-09-1412, sample 08LO01-3.

Figures 20-21 *Samarella* sp.2; 20 right lateral view of the complete carapace, SUT-09-1413, sample 07LB05-D2; 21 right lateral view of the complete carapace, SUT-09-1414, sample 07LB05- D2.

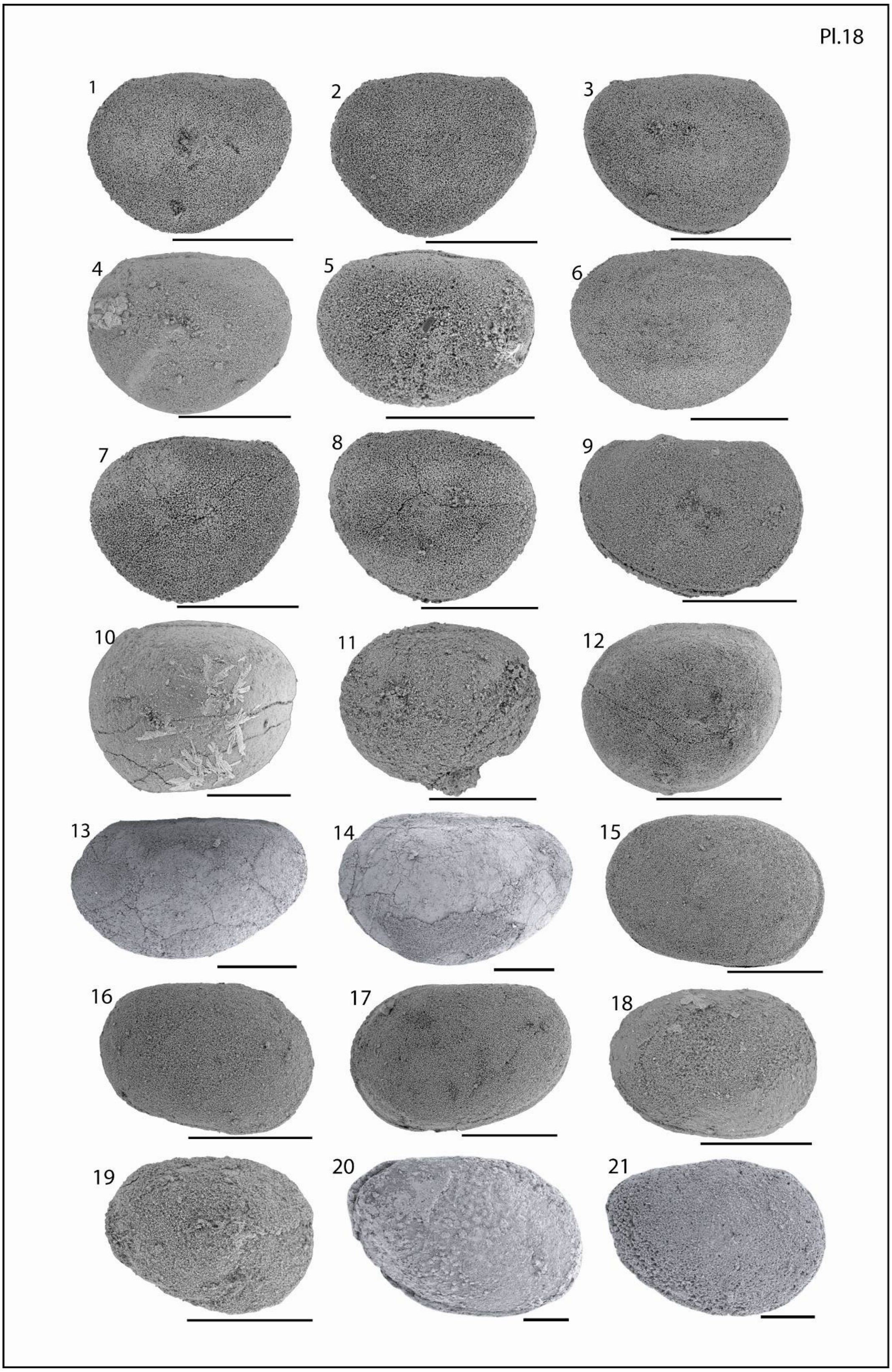
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Plate 19

(Scale bars are 300 μm except for 15 where it is 200 μm, for 16, 18 where it is 500 μm)

Figure 1 *Paraparchites* sp.3; left lateral view of the complete carapace, SUT-09-1415, sample 08PB01.

Figures 2-3, 6 Paraparchitidae sp.?; 2 left lateral view of the incomplete carapace, SUT-09-1416, sample 07LB04-16; 3 side-inclined view of the complete carapace, SUT-09-1417, sample 07LB04-16; 6 left dorsal view of the complete carapace, SUT-09-1418, sample 07LB04-16.

Figure 4 *Kirkbya* sp.1; left lateral view of the complete carapace, SUT-09-1419, sample 07PB03-5.

Figure 5 *Kirkbya* sp.2; left lateral view of the incomplete carapace, SUT-09-1420, sample 07PB03-5.

Figure 7 *Kirkbya* sp.3; left lateral view of the incomplete carapace, SUT-09-1421, sample 08LO02-5.

Figures 8-9 *Knightina* sp.1; 8 right lateral view of the incomplete carapace, SUT-09-1422, sample 07LB05-D2; 9 right lateral view of the incomplete carapace, SUT-09-1423, sample 07LB05-C1.

Figure 10 *Knightina* sp.2; right lateral view of the incomplete carapace, SUT-09-1424, sample 07LB08-1.

Figure 11 *Knightina* sp.3; right lateral view of the incomplete carapace, SUT-09-1425, sample 08LO02-2.

Figures 12-15 *Knightina* sp.4; 12 right lateral view of the complete carapace, SUT-09-1431, sample 07PB08-2; 13 left lateral view of the incomplete carapace, SUT-09-

1433, sample 07PB04-5; 14 right lateral view of the incomplete carapace, SUT-09-1434, sample 08PB01; 15 left lateral inclined view of the incomplete carapace, SUT-09-1432, sample 07LB05-D2.

Figures 16-17 *Reviya subsompongensis* Chitnarin, 2008; 16 left lateral view of the incomplete carapace, SUT-09-1426, sample 08PB02-6; 17 right lateral view of the incomplete carapace, SUT-09-1427, sample 08PB03-3.

Figure 18 Kellettinidae sp.; right lateral view of the incomplete carapace, SUT-09-1430, sample 07PB04-2.

Figures 19-20 *Polytylites* sp; 13 left lateral view of the complete carapace, SUT-09-1428, sample 08LO07-1; 14 left lateral view of the incomplete carapace, SUT-09-1429, sample 08LO07-8.

Figure 21 *Shleesha* sp.1; lateral view of the incomplete carapace, SUT-09-1435, sample 08LO07-1.

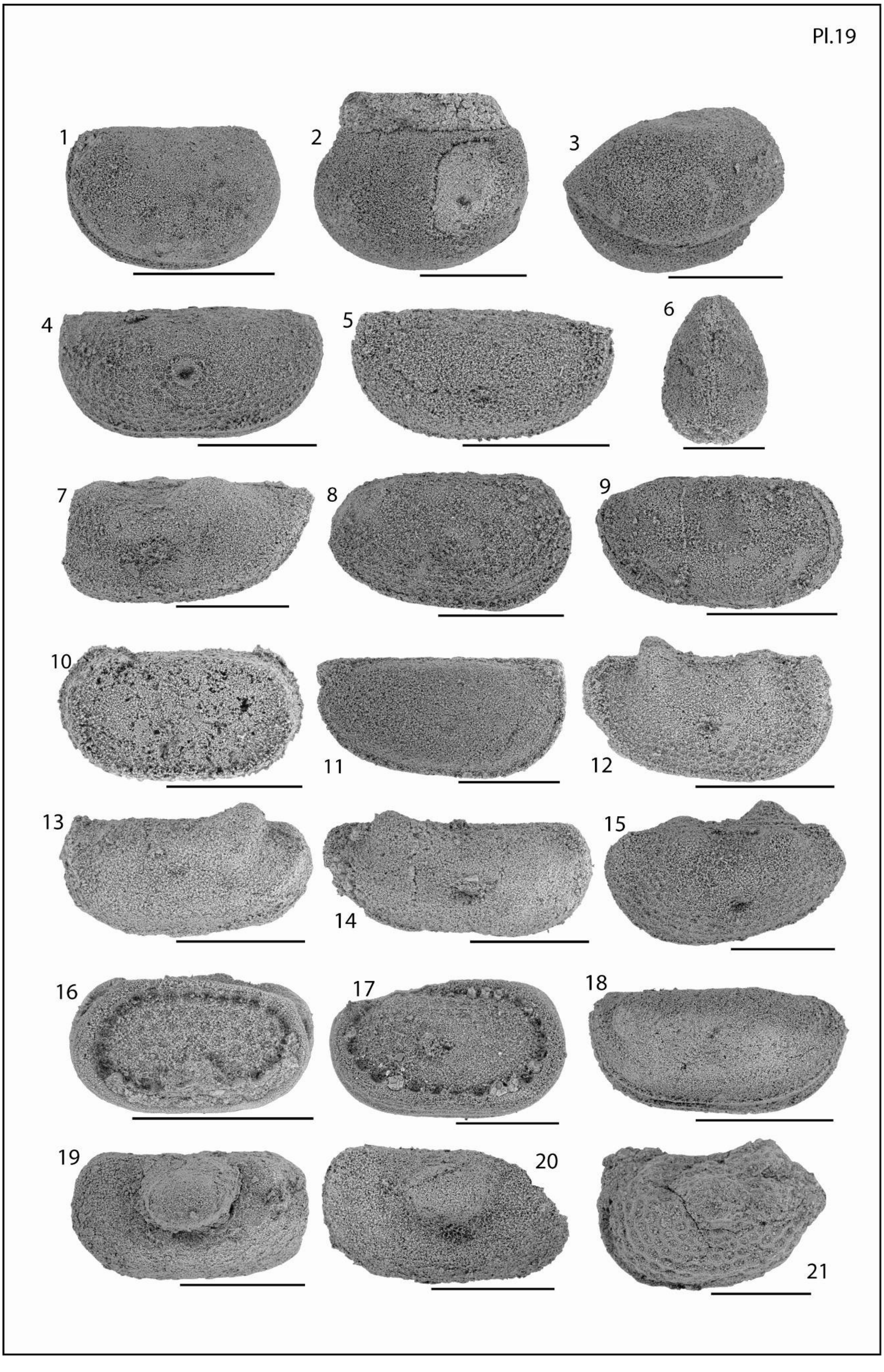
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Plate 20

(Scale bar is 300 µm except for 3, 6, 9, 12, 15 where it is 500 µm, for 8 where it is 200 µm)

Figure 1 *Knoxiella* sp.1; left lateral view of the complete carapace, SUT-09-1436, sample 07LB05-D1.

Figures 2-3 *Knoxiella* sp.2; 2 left lateral view of the complete carapace, SUT-09-1437, sample 07PB03-5; 3 left lateral view of the complete carapace, SUT-09-1438, sample 07PB05-6.

Figures 4-6 *Geisina* sp.1; 4 left lateral view of the complete carapace, SUT-09-1439, sample 07LB05-B1; 5 left lateral view of the complete carapace, SUT-09-1440, sample 07LB05-B1; 6 right lateral view of the complete carapace, SUT-09-1441, sample 07PB03-3.

Figure 7 *Eukloedenella*? sp.1; left lateral view of the incomplete carapace, SUT-09-1442, sample 08KB03-4.

Figure 8 *Eukloedenella*? sp.2; left lateral view of the complete carapace, SUT-09-1443, sample 07LB05-B3.

Figures 9, 12, 15 *Sargentina* sp.1; 9 left lateral view of the incomplete carapace, SUT-09-1444, sample 07PB03-3; 12 left lateral view of the complete carapace, SUT-09-1445, sample 07PB03-3; 15 left lateral view of the complete carapace, SUT-09-1446, sample 07PB03-3.

Figures 10-11, 13-14 *Sargentina* sp.2; 10 left lateral view of the complete carapace, SUT-09-1447, sample 07PB03-3; 11 left lateral view of the complete carapace, SUT-09-1448, sample 07PB03-3; 13 left lateral view of the complete carapace, SUT-09-

1449, sample 07PB03-3 right lateral view of the complete carapace, SUT-09-1450, sample 07PB03-3.

Figures 16-18 *Geffenina* sp.1; 16 left lateral view of the complete carapace, SUT-09-1451, sample 07PB03-3; 17 left lateral view of the complete carapace, SUT-09-1452, sample 07PB03-7; 18 right lateral view of the complete carapace, SUT-09-1453, sample 07PB03-5.

Figures 19-21 *Geffenina* sp.2; 19 left lateral view of the complete carapace, SUT-09-1454, sample 07LB04-17; 20 left lateral view of the complete carapace, SUT-09-1455, sample 07LB04-17; 21 left lateral view of the incomplete carapace, SUT-09-1456, sample 07LB04-17.

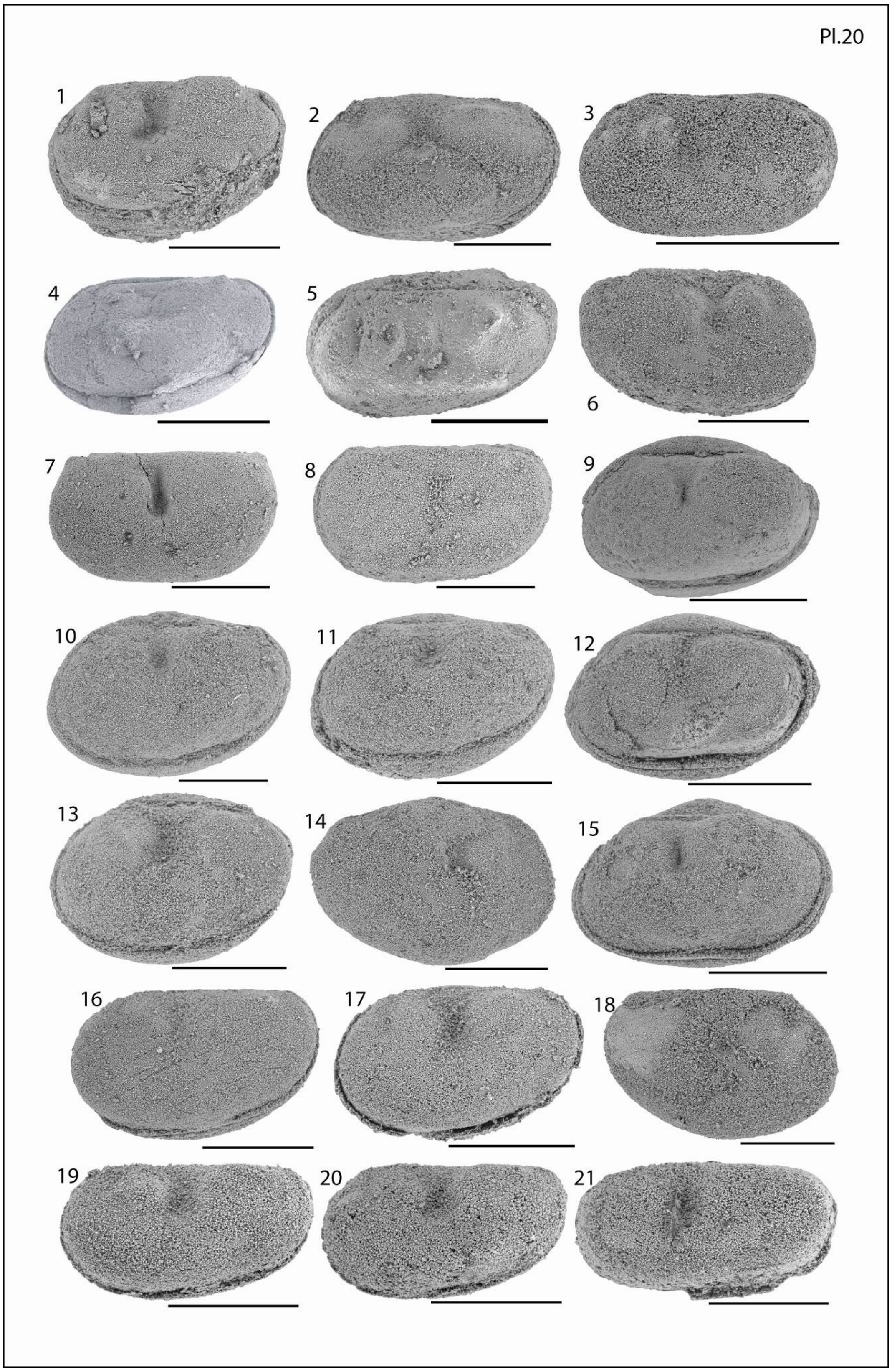
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Plate 21

(Scale bar is 300 µm except for 4, 6 where it is 500 µm)

Figures 1-5 *Langdaia* sp.1; 1 left lateral view of the complete carapace, SUT-09-1457, sample 08LB01-3; 2 left lateral view of the complete carapace, SUT-09-1458, sample 08LB01-1; 3 left lateral view of the complete carapace, SUT-09-1459, sample 08LB01-1; 4 dorsal view of the complete carapace, SUT-09-1460, sample 08LB01-1; 5 right lateral view of the complete carapace, SUT-09-1461, sample 08LB01-1.

Figures 6, 10 Kloedenellcea indet.; 6 left lateral view of the complete carapace, SUT-09-1469, sample 08LO02-11; 10 dorsal view of the complete carapace, SUT-09-1470, sample 08LO02-11.

Figures 7-9 *Eukloedenella*? sp.1; 7 right lateral view of the complete carapace, SUT-09-1462, sample 08LB01-1; 8 dorsal view of the complete carapace, SUT-09-1463, sample 07LB09-1; 9 left lateral view of the incomplete carapace, SUT-09-1464, sample 07LB09-1.

Figures 11-12 *Eukloedenella*? sp.2; 11 right lateral view of the complete carapace, SUT-09-1465, sample 07LB05-C1; 12 left lateral view of the complete carapace, SUT-09-1466, sample 07LB05-C1.

Figures 13, 16 *Kloedcytherella oertlii* Kozur, 1985; 13 right lateral view of the incomplete carapace, SUT-09-1471, sample 08PB02-4; 16 left lateral view of the complete carapace, SUT-09-1472, sample 08LB01-1.

Figures 14-15 *Eukloedenella*? sp.3; 14 right lateral view of the incomplete carapace, SUT-09-1467, sample 07LB05-A1; 15 right lateral view of the incomplete carapace, SUT-09-1468, sample 07LB05-A3.

Figures 17-19 *Permoyoungiella* sp.1; 17 right lateral view of the complete carapace, SUT-09-1473, sample 08LO02-2; 18 right lateral view of the complete carapace, SUT-09-1474, sample 07PB04-2; 19 right lateral view of the complete carapace, SUT-09-1475, sample 07PB04-5.

Figures 20-22 *Orthocypris*? sp.; 20 right lateral view of the incomplete carapace, SUT-09-1476, sample 08LO07-2; 21 right lateral view of the complete carapace, SUT-09-1477, sample 08LO07-2; 22 dorsal view of the complete carapace, SUT-09-1478, sample 08LO07-2.

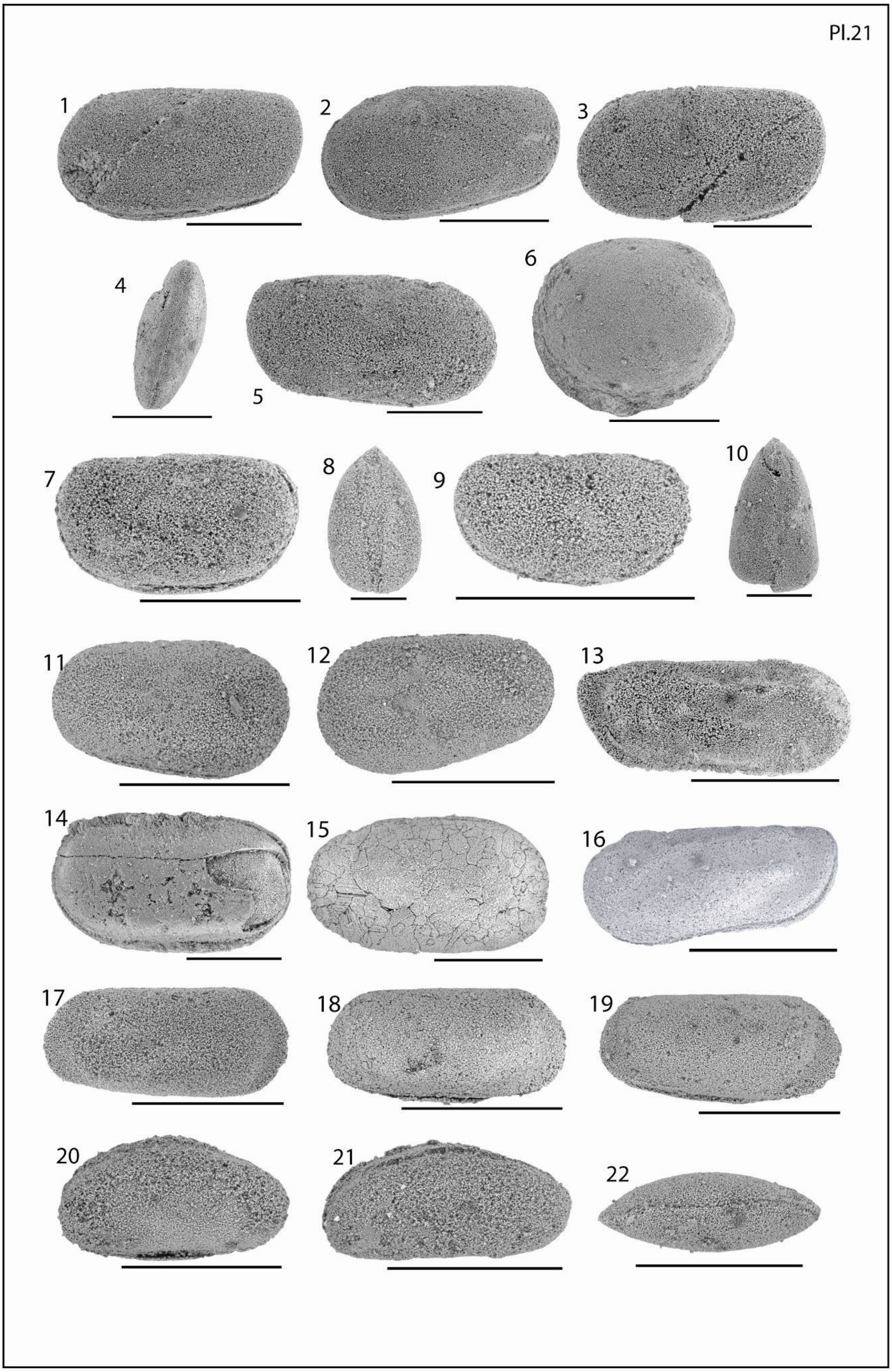
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Plate 22

(Scale bar is 300 µm except 3, 5-8 where it is 500 µm)

Figures 1-4 *Hollinella martensiformis* Crasquin, 2010; 1 left lateral view of the complete carapace, SUT-09-1479, sample 07PB03-3; 2 left lateral view of the complete carapace, SUT-09-1480, sample 07PB03-5; 3 right lateral view of the complete carapace, SUT-09-1481, sample 07PB03-3; 4 left lateral view of the complete carapace, SUT-09-1482, sample 07PB04-5.

Figures 5-6 *Hollinella (Hollina) herrickana* (Girty, 1909); 5 right lateral view of the incomplete carapace, SUT-09-1483, sample 08PB03-2; 6 right lateral view of the incomplete carapace, SUT-09-1484, sample 08PB03-3.

Figures 7-8 *Hollinella (Hollina) herrickana*? sp.; 7 left lateral view of the incomplete carapace, SUT-09-1485, sample 07PB03-3; 8 right lateral view of the incomplete carapace, SUT-09-1486, sample 07PB03-3.

Figure 9 *Hollinella (Hollinella)*? sp.; right lateral view of the incomplete carapace, SUT-09-1487, sample 08PB03-3.

Figure 10 A sectioned ostracod carapace and limestone texture of the sample No.07PB03-2.

Figure 11 A sectioned ostracod carapace and limestone texture of the sample No.07PB04-2.

Figure 12 A sectioned ostracod carapace and limestone texture of the sample No.08PB02-12.

Figure 13 A sectioned ostracod carapace and limestone texture of the sample No.07LB05-A1.

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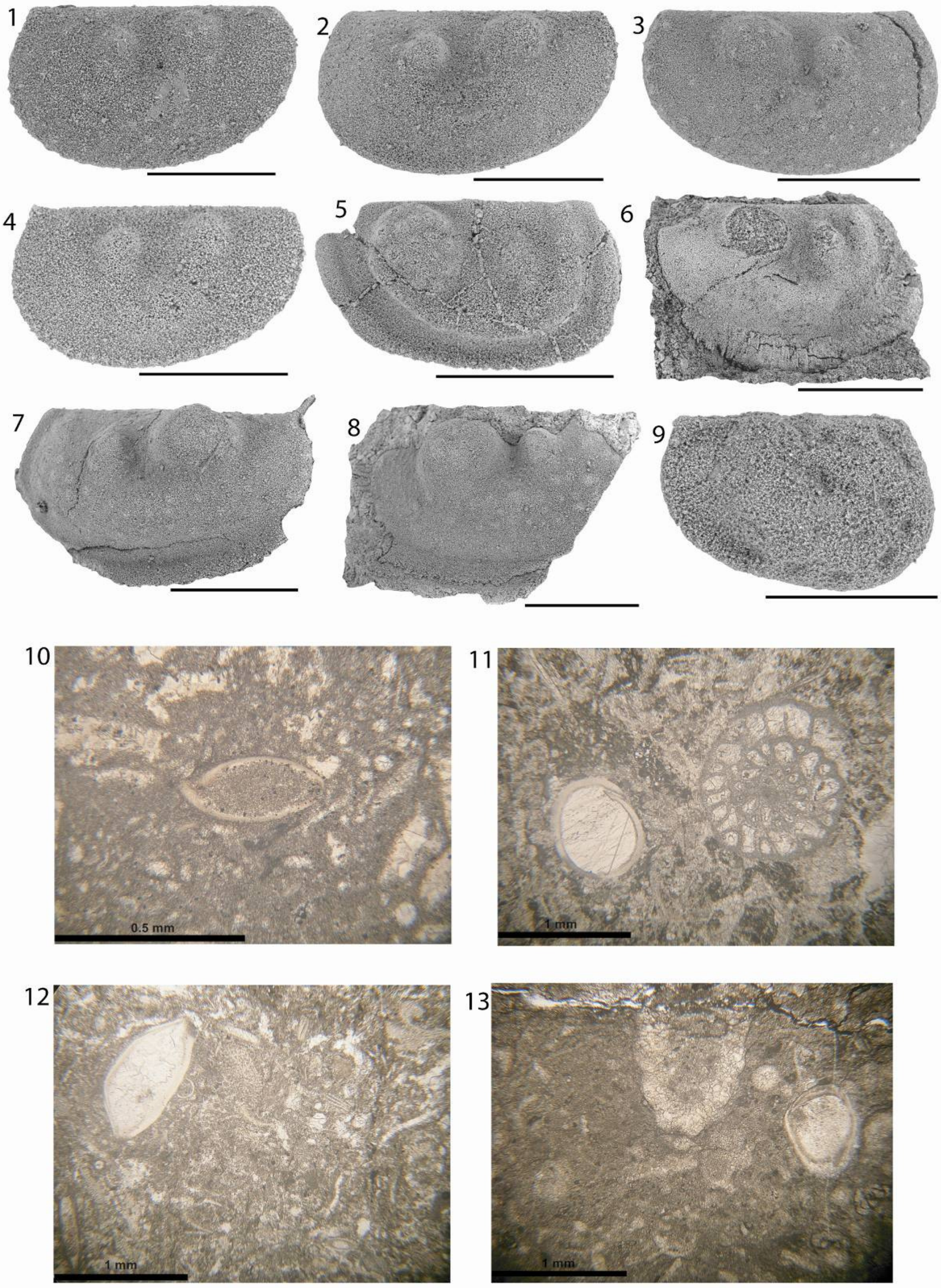

CURRICULUM VITAE

Miss Anisong Chitnarin was born on July 11th, 1978 in Chiang Mai Province, northern Thailand. She was educated at Dara Academy before attending Chiang Mai University where she completed a Bachelor of Science degree in Geology in 1999. Then, she started her career as an environmental scientist at S.P.S Consulting Service Co. Ltd., in Bangkok before she joined Chula Unisearch, Chulalongkorn University in 2001. She became a graduate student at Suranaree University of Technology, Nakhon Ratchasima in 2003 where she got a Master of Science degree in Environmental biology in 2005. During her graduate study, she was a research and teacher assistant for School of Geotechnology and School of Biology, respectively. She started her Ph.D. dissertation on Thai Permian ostracods in 2006 which was supported by grant fund under the program Strategic Scholarships for Frontier Research Network for the Ph.D. Program Thai Doctoral degree from the Office of the Higher Education Commission, Thailand.