Zootaxa 5162 (4): 301–356
https://www.mapress.com/zt/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.5162.4.1
http://zoobank.org/urn:lsid:zoobank.org:pub:DD2279FA-E8F1-4951-A5CA-91082E875580

Revision of F. R. C. Reed's Ordovician trilobite types from Myanmar (Burma) and western Yunnan Province, China

RICHARD A. FORTEY[1], SHELLY J. WERNETTE[2,3] & NIGEL C. HUGHES[2,4]
[1]*Department of Earth Sciences, Museum of Natural History, Cromwell Road, London, SW7 5BD, UK.*
r.fortey@nhm.ac.uk; https://orcid.org/0000-0001-8917-3706
[2]*Department of Earth and Planetary Sciences, University of California, Riverside, CA 92521, USA.*
[3]*Department of Geography and Environmental Studies, Texas State University, San Marcos, TX 78666, USA*
swern001@ucr.edu; https://orcid.org/0000-0003-0078-4717
[4] *nigel.hughes@ucr.edu; https://orcid.org/0000-0001-9671-5569*

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Accepted by J. Adrain: 20 May 2022; published: 8 Jul. 2022

Abstract

The field collections made from Burma (Myanmar) by the Geological Survey of India, and described by F.R.C. Reed more than a century ago, still provide the only 'ground truthing' for an important region of the Ordovician marginal terranes fringing Gondwana. A revision of these faunas is overdue, particularly as it is likely that further collections cannot be made in the northern Shan State in the near future. The specimens, stored in the Geological Survey of India collections in Kolkata, cannot be loaned. Sixteen species are fully revised herein; another twelve species are left under open nomenclature because of inadequacies in the material. Several of Reed's species subsequently became type species of genera that have proved to be widespread: *Birmanites* Sheng, 1934, *Encrinurella* Reed, 1915, *Neseuretinus* Dean, 1967, and *Pliomerina* Chugaeva, 1956. Reed's Ordovician trilobite collections came from two main areas: northern Shan State (Myanmar), and westernmost Yunnan (China). The Burmese (Myanmar) collections are from the Upper Ordovician (Katian) while Yunnan specimens are from the Middle Ordovician (Darriwilian), though Upper Ordovician trilobites also occur in the area. Both collections are predominantly from clastic strata. Based on a small new Katian collection from Pupiao, we report *Neseuretinus birmanicus* (Reed, 1906) in common between the northern part of the Shan State and western Yunnan. A few genera (*Dionide* Barrande, 1847, *Phorocephala* Lu, 1957*, Lonchodomas* Angelin, 1854*, Nileus* Dalman, 1827) are distributed worldwide, and include pelagic (*Phorocephala*) or deeper benthic (*Dionide*) taxa. The palaeogeographic comparisons offered by the other taxa are mostly peri-Gondwanan and extend from southwest China westwards (present geography) as far as the Iberian Pennsula. *Birmanites* is the type genus of a subfamily (Birmanitinae Kobayashi, 1960, revived herein) widely distributed over Ordovician Gondwana, and absent from Laurentia, Baltica and North China/Siberia. *Mioptychopyge* Zhou, Dean, Yuan & Zhou, 1998, probably belongs with the same group and is otherwise known from South China. *Parillaenus* Jaanusson, 1954, is also peripheral Gondwanan, as is *Prionocheilus* Rouault, 1847. The Reedocalymeninae Kobayashi, 1951 (*Neseuretinus, Reedocalymene* Kobayashi, 1951) are similarly diagnostic of peri–Gondwanan sites. However, some genera (*Pliomerina*, *Encrinurella, Ovalocephalus* Koroleva, 1959) have been associated with other oriental and Australian occurrences in particular, with 'outliers' in certain terranes in Kazakhstan, i.e. palaeotropical Gondwana.

Key words: Trilobita, Palaeogeography, Ordovician, Sibumasu, Baoshan

Introduction

During the earlier part of the twentieth century Frederick Richard Cowper Reed (1869–1946) published a series of papers in the journal *Palaeontologia Indica* describing Lower Palaeozoic fossils from localities collected by officers of the Geological Survey of India. At that time these were pioneering studies in what were areas remote from previous exploration by palaeontologists, and many of the taxa proved to be new; some of these in turn became type species of genera that have subsequently been widely reported. Trilobites were Reed's particular area of expertise, and proved to be common and varied in some Ordovician localities. Those that were recovered from the northern part of the Shan State of Myanmar (then Burma) (Figs 1,2,3) and the adjacent part of China in western Yunnan Province (Figs 1,2,4) comprise the subject of this revision (Reed, 1906, 1915, 1917). The Geological Survey of India is based in Kolkata (Calcutta) where *Palaeontologia Indica* was published. After the departure of the British when India achieved independence, the fossils remained in Kolkata, curated in the holdings of the Geological Survey of India (GSI), where they still reside. The GSI repository and associated Indian Museum does not currently lend out type specimens, and Reed's original publications are not easy to obtain. Nor have these trilobite species been photographically illustrated. This paper is intended to make information on these Ordovician species more widely available and to update their taxonomy. This work is timely, as the Lower Palaeozoic rocks of Myanmar are becoming more open to renewed palaeontological exploration (Aye Ko Aung, 2012; Aye Ko Aung & Cocks, 2017; Wernette *et al.*, 2021), while Reed's work still forms the basis of field determinations. However, as this is written (2022) political upheaval in Myanmar makes it very unlikely that the northern parts of Shan State can be visited by foreigners. This reinforces the relevance of the material curated in the Geological Survey of India in understanding the Ordovician stratigraphy in an important, but understudied area. One part of the collection has already been revised: the assemblage of the Panghsa-pye Formation that includes the uppermost Ordovician was treated by Cocks & Fortey (2002) and does not require further revision at this time.

The Reed Collections

Although much of the material was likely collected by GSI officers, Reed did visit Myanmar (Woods, 1946) where presumably he went into the field. In 1998 RAF and NCH visited the repository of the Geological Survey of India in Kolkata and were permitted to examine Reed's Burmese types, which carry registration numbers quoted in the text and figure explanations. It was possible to make latex casts of many of these specimens. Comparison with the drawings of them made originally by T. C. Brock proved that he was a good and accurate artist, and in general served Reed well. Some specimens had deteriorated, or were too fragile to apply latex, and in some of these cases we are obliged to reproduce Brock's illustrations. On return to the Natural History Museum in London, casts were taken from these latexes; the casts were then treated with sublimated ammonium chloride and photographed. Several of Reed's type specimens were tectonically distorted. SW retrodeformed the few specimens with adequate features to construct the strain ellipsoid required for objective restoration. Strain markers include two specimens in different orientations (e.g. Figs 12.10a & b) or one specimen with strain lineations (e.g. Figs 9.2a & b) (Ramsay & Huber, 1983; Hughes & Jell, 1992). Where objective retrodeformation was not feasible, for most species there were undistorted examples of the same taxon that served as a model for restoration of distorted individual specimens. For example, *Birmanites birmanicus* (Reed, 1915) has one apparently undistorted incomplete dorsal exoskeleton (Fig. 6.6) which acts as a template for retrodeforming a cephalic shield which is obviously transversely 'stretched' (Fig. 6.2a). The same principle permits straightening an obliquely distorted specimen with a pygidium (Fig. 6.4). For retrodeformed specimens the original is indicated by the figure number (e.g. Fig. 6.2a) and the restoration by the letter 'b' (e.g. Fig. 6.2b). Because the restoration is not a real entity no scale bar is given for it.

Geological setting

The Burmese and Yunnan collections examined by Reed fall into three geographical groups: 1. northern part of Shan State (Myanmar); 2. southern part of Shan State, 3. western Yunnan (China). All belong to the upland region that forms the eastern part of Myanmar (Burma) and the western edge of southwest China. Relatively fragmentary trilobite material from the southern part of the Shan State is not re-described herein. Tectonically this area is part of the ancient Sibumasu terrane (Metcalfe, 1984) (Figs 1, 2), a unit that rifted off the peri-Gondwanan margin with the opening of the Meso-Tethys ocean in the Permian, and collided with South China during the Triassic (Metcalfe, 2017). During the earlier Ordovician, the crust that later became Sibumasu apparently lay adjacent to the western Australian sector of equatorial peri-Gondwana (Wernette *et al.*, 2021). The Baoshan Block of western Yunnan (Figs 1, 2), from which some of the Reed specimens originate, has a somewhat different stratigraphy from that of the Shan-Thai sector of Sibumasu and, if it was part of Sibumasu at that time, was likely situated toward its western margin. Evidence for this is that Baoshan shares a distinctive, marked Cambrian-Ordovician unconformity otherwise characteristic of the Himalayan sector of the Gondwana margin (Myrow *et al.*, 2016; Wernette *et al.*, 2021) and also the Simao/Ailaoshan block (Wang *et al.*, 2014).

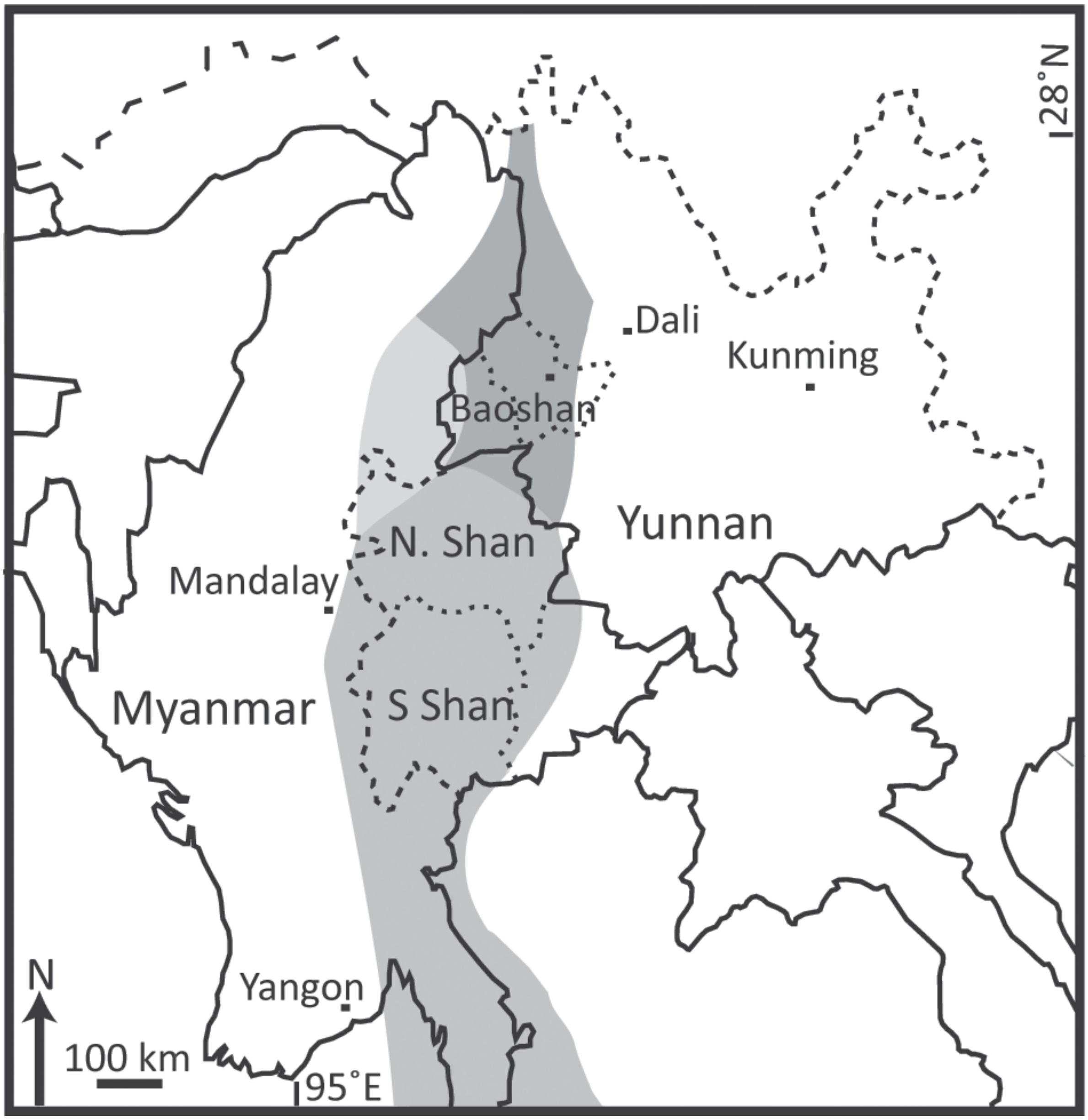

FIGURE 1. The modern configuration of the northern part of the Sibumasu terrane with the Baoshan (darkest gray shading) and Tenchong (lightest gray shading) blocks differentiated. Modified from Wernette *et al.* (2021, fig. 1), where these units are discussed.

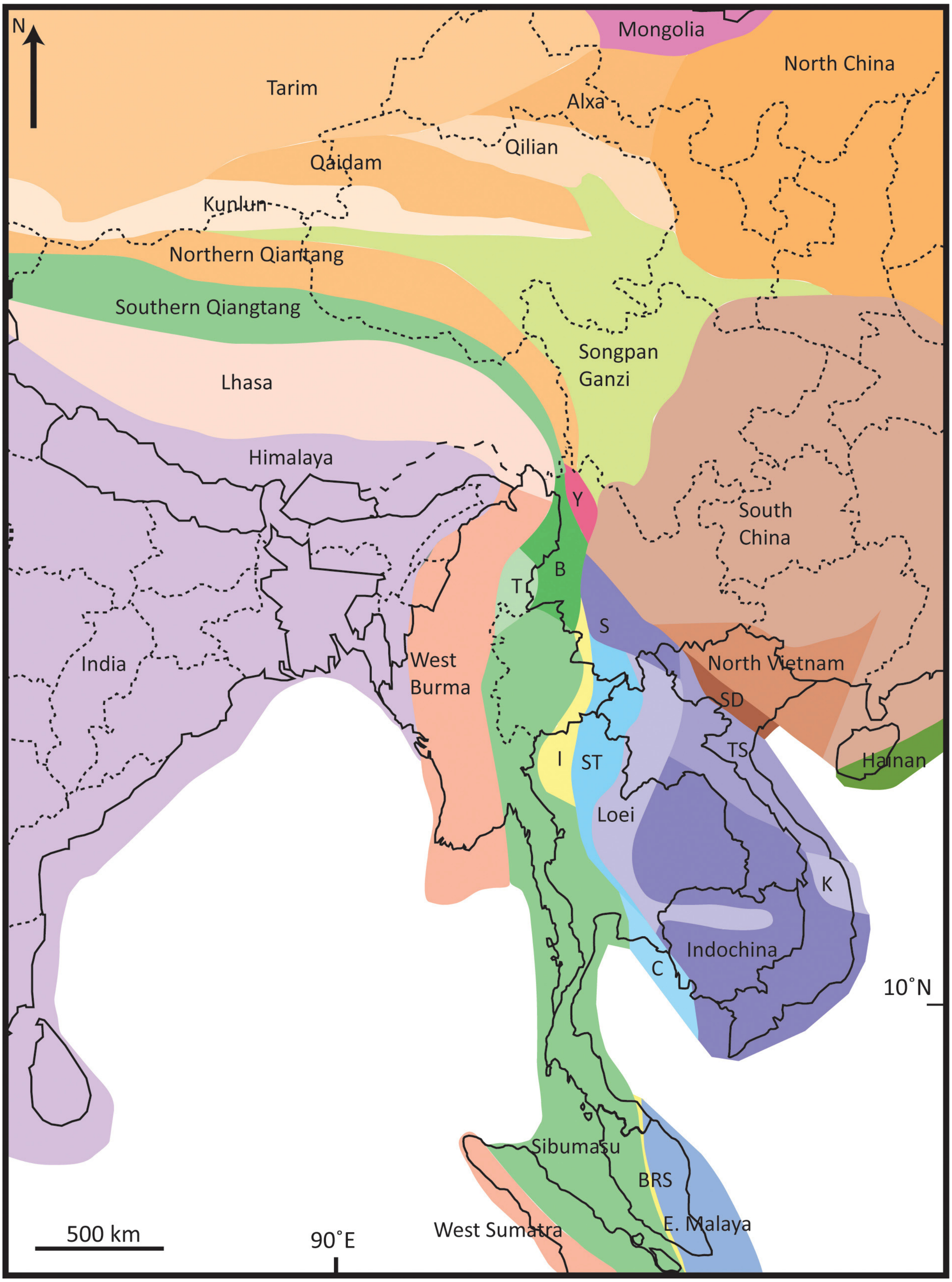

FIGURE 2. Asian Equatorial Gondwanan terranes in their modern configuration and regional context. Modified from Metcalfe (2011, 2017), Burrett *et al.* (2014) and Loydell *et al.* (2019). B = Baoshan, BRS = Bentong-Raub suture zone, C = Chanthaburin, I = Inthanon, K= Kon Tum, S = Simao/Ailaoshan, ST = Sukhothai, TS = Trýờng Sõn, SD = Sông Đà, T = Tengchong, Y = Yunling. The terranes commonly considered to constitute greater Indochina, as shown here, also include Loei, Trýờng Sõn, Simao, and Kon Tum.

In the Palaeozoic it is generally accepted that a series of peri-Gondwana terranes rifted off the margin in succession with the opening of the Palaeo-Tethys and Meso-Tethys oceans (Metcalfe, 2017), but the early Palaeozoic structure of the peri-Gondwanan margin is currently the subject of debate (Wernette *et al.*, 2021). Some have argued that in the Cambrian a branch of the wide equatorial ocean lying between Gondwana and Siberia/Baltica, the Proto-Tethys, separated continental material from the equatorial Gondwanan margin, and that the widespread swath of Cambrian-Ordovician granites that rim that margin (e.g. Zhu *et al.*, 2012; Lin *et al.*, 2013) represent the suturing of that crust at that time (see discussion in Wernette *et al.*, 2021). Regardless of this issue, a combination of sediment provenance, palaeontological, stratigraphic and palaeomagnetic data has suggested that the sectors of the peri-Gondwanan margin that lay "outboard" of Sibumasu prior to the Middle Devonian opening of Palaeo-Tethys (Metcalfe, 2017), included both North and South China. Faunal links with North China appear to be the strongest throughout the earlier Palaeozoic (Burrett *et al.*, 2016), but marked association with South China is also evident both in the Cambrian (Wernette *et al.,* in revision) and particularly in the later Ordovician (Fortey, 1997; Cocks *et al.,* 2005).

Stratigraphy

Northern part of Shan State (Fig. 3).

The stratigraphical succession of Myanmar's Shan Plateau (Fig. 5) begins with the Precambrian Chaung Magyi Group, a series of mildly metamorphosed whitish-gray siltstones and fine-grained sandstones (Reed, 1906; Myint Lwin Thein, 1973; Aye Ko Aung & Cocks, 2017). This is unconformably overlain by the Furongian Pangyun Formation in the northern part of the Shan State and correlative Molohein Group in the southern part. These units also comprise siltstones and quartzarenites, with a higher proportion of quartzarenites than occurs in the Chaung Magyi (Aye Ko Aung & Cocks, 2017; Wernette *et al.*, 2021). Reed did not know about the existence of Cambrian trilobites in Myanmar, which were not discovered until the 1970s (Myint Lwin Thein, 1973; Thaw Tint, 1972) and first formally described by Wernette *et al.* (2021).

Studies of Myanmar to date suggest that deposition of the Naungkangyi Group and the correlative Pindaya Group of the southern Shan State started at the beginning of the Tremadocian (Myint Lwin Thein, 1973; Aye Ko Aung & Cocks, 2017) and extended to the Hirnantian. However, NCH and SJW recently collected Tremadocian fossils from southern Shan's Molohein Group, suggesting that the base of the Pindaya Group is middle or late Tremadocian. This mirrors the mid-Tremadocian transition of Thailand's Tarutao Group to Thung Song Group (Stait *et al.,* 1984), and northern Shan's Pangyun to Naungkangyi transition likely also follows this pattern. The Naungkangyi Group extends from the Lower Ordovician to the base of the Hirnantian, and is conformably overlain by the Hirnantian and Silurian Panghsapye Formation (Aye Ko Aung & Cocks, 2017). The Kushwe-e-we Formation is the Naungkangyi Group's correlative in the Kayin Region of Myanmar (Udchachon *et al.*, 2018).

The lowest unit of the Naungkangyi Group is the Early Ordovician Lokepyin Formation which extends into the southern Shan State. This formation is ~912m thick in the northern part of Shan State and primarily consists of yellowish-brown siltstones in the east; in the western part of the Shan platform the Lokeypin Formation is characterized by blue limestones with siltstones occurring only as thin partings between limestone beds (Aye Ko Aung & Cocks, 2017).

The Lokepyin Formation grades into the Dapingian to Sandbian Sitha Formation of the northern part of Shan State. Medium to thick-bedded limestones ranging from dark gray to blue may have some interbedded yellow to purplish-brown siltstones. Some horizons have burrow structures or are oolitic. The Wunbye Formation, the correlative formation in the southern Shan State, differs only slightly from the Sitha Formation in having limestones that are more finely crystalline and more dolomitic (Aye Ko Aung & Cocks, 2017). The Sitha and Lokepyin formations in combination equate to the Lower Naungkangyi Beds (Reed, 1915). The fauna Reed published from the Lower Naungkangyi Beds seems to be restricted to the Darriwilian.

The uppermost, Katian formation of the Naungkangyi Group is defined differently in the northern part of the Shan State than in the middle, what Aye Ko Aung and Cocks (2017) call the "Pyin Oo Lwin area". The Kunlein Formation, found around Pyin Oo Lwin and in the mountains to the south of the Myitnge River (Fig. 3) is very similar to the Li-Lu Formation found further north. A notable difference is that the latest Katian Hwe Mawng Beds (Reed, 1915) form a prominent uppermost member of the Kunlein Formation but are absent from the Li-Lu Formation (Aye

Ko Aung & Cocks, 2017). The Li-Lu and Kunlein formations are Reed's (1915) Upper Naungkangyi Beds and are fine-grained siliciclastics, including well-bedded siltstone and claystone as well as calcareous shale with limestone lenses. The Hwe Mawng Beds consist of purple shale (Reed, 1915). All northern Shan fossils discussed herein are from the Lilu and Kunlein formations, especially the Hwe Mawng Beds.

At or near the end of the Ordovician the Naungkangyi Group transitioned into the Panghsapye Formation. Originally, the Panghsapye Shales and Nyaungbaw Limestones were treated as separate formations. Justification for this included their distinctive lithologies and differing faunas, the Panghsapye Shales being graptolitic. More recent work treats them as a single unit, collectively called the Panghsapye Formation (Aye Ko Aung & Cocks, 2017). Reed (1906, 1915) recorded an Ordovician age for the Nyaungbaw Limestones. The lowest limestone horizons have been confirmed as Hirnantian, but most of the formation is Silurian in age (Cocks & Fortey, 2002; Aye Ko Aung & Cocks, 2017). The limestones are mostly red and gray with fossils attributed by Reed (1906) to *Camarocrinus* Hall, 1879 and *Orthoceras* Bruguière, 1789. The shales are found in a single band, ~15m thick and are white, with abundant graptolites (Cocks & Fortey, 2002).

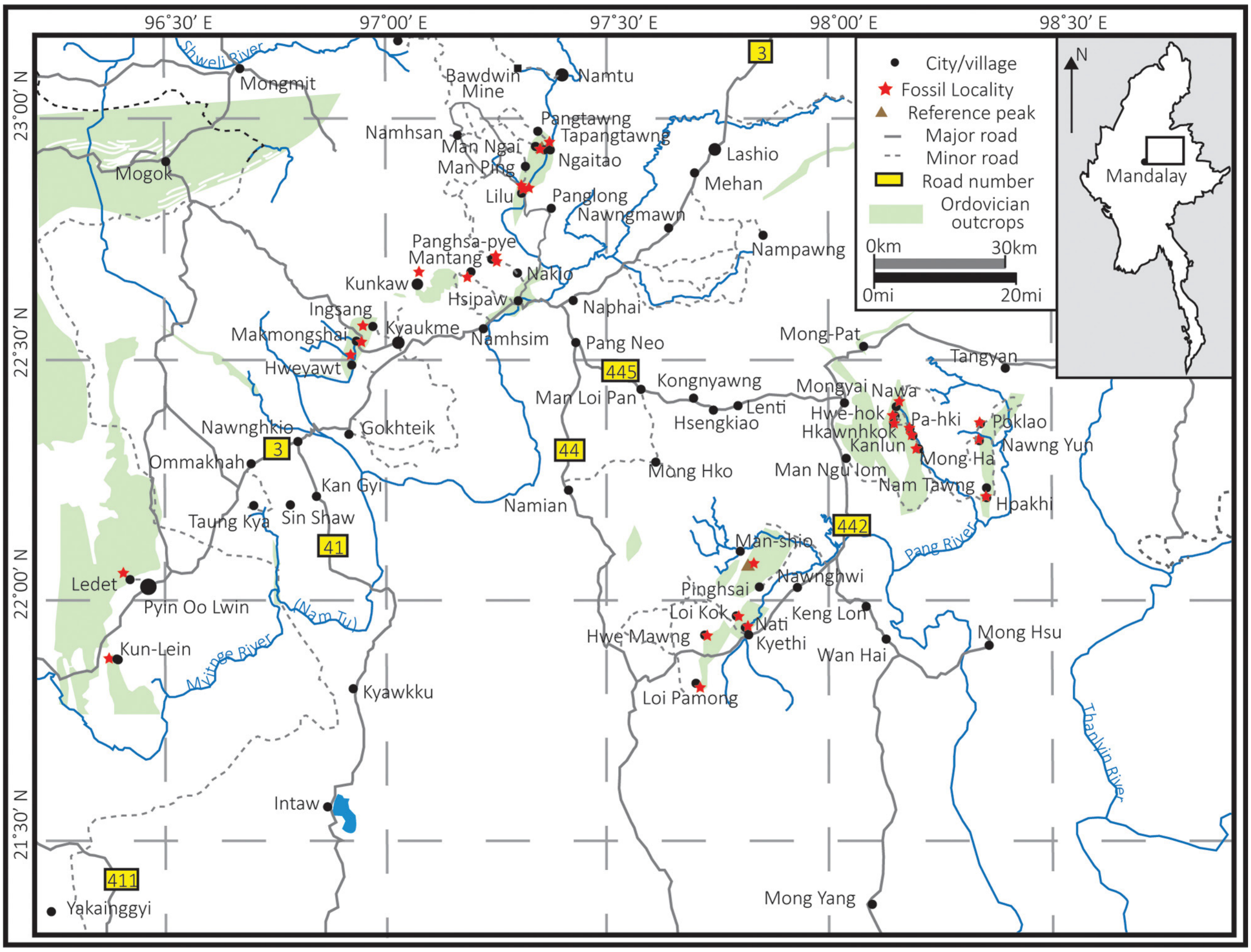

FIGURE 3. Map of the northern part of Myanmar's Shan State. Areas designated as Ordovician outcrops follow LaTouche (1913). See text for further information about individual fossil localities.

Western Yunnan (Fig. 4)

The geology and stratigraphy of Yunnan is highly complex, especially in the western part of the province where the South China, Simao, Indochina, and Sibumasu blocks all converge (Fig. 2), each bringing with them their individual stratigraphic histories (Zhang *et al.*, 2014). Accordingly, stratigraphic nomenclature varies between each of these terranes, but also within them. Because all the fossils that Reed described (1917) come from the area around Baoshan city, and no further south than Shidian, only the Baoshan area is considered here (Fig. 5). Reed (1917) described the trilobite assemblage from the Shihtien Formation, which is Darriwilian in age.

The regional setting is as follows. The Baoshan Formation has an abundant record of Cambrian Stage 10 trilobite fauna including *Eosaukia* Lu, 1954, *Quadraticephalus* Sun, 1924, and *Lophosaukia* Shergold, 1972 (Sun & Xiang, 1979). These genera are shared with Myanmar and Thailand, but also occur throughout northernmost Cambrian Gondwana (Kobayashi, 1957; Sun & Xiang, 1979; Shergold *et al.*, 1988; Wernette *et al.*, 2021; Wernette *et al.*, in revision). Other regionally important trilobite taxa (e.g. *Kaolishania* Sun, 1924 and *Parachangshania* Qian, 1958 (see Sun & Xiang, 1979) have not yet been found elsewhere in Sibumasu (Wernette *et al.*, 2021), providing a notable difference between the Baoshan succession and that of Myanmar and Thailand, and possibly indicating an older set of Cambrian strata than has been found in these other areas. It is presently unclear whether the siliciclastic Baoshan Formation extends into the Lower Ordovician as in the correlative Molohein and Tarutao groups in Myanmar and Thailand respectively (Stait *et al.*, 1984; Wernette *et al.*, in revision).

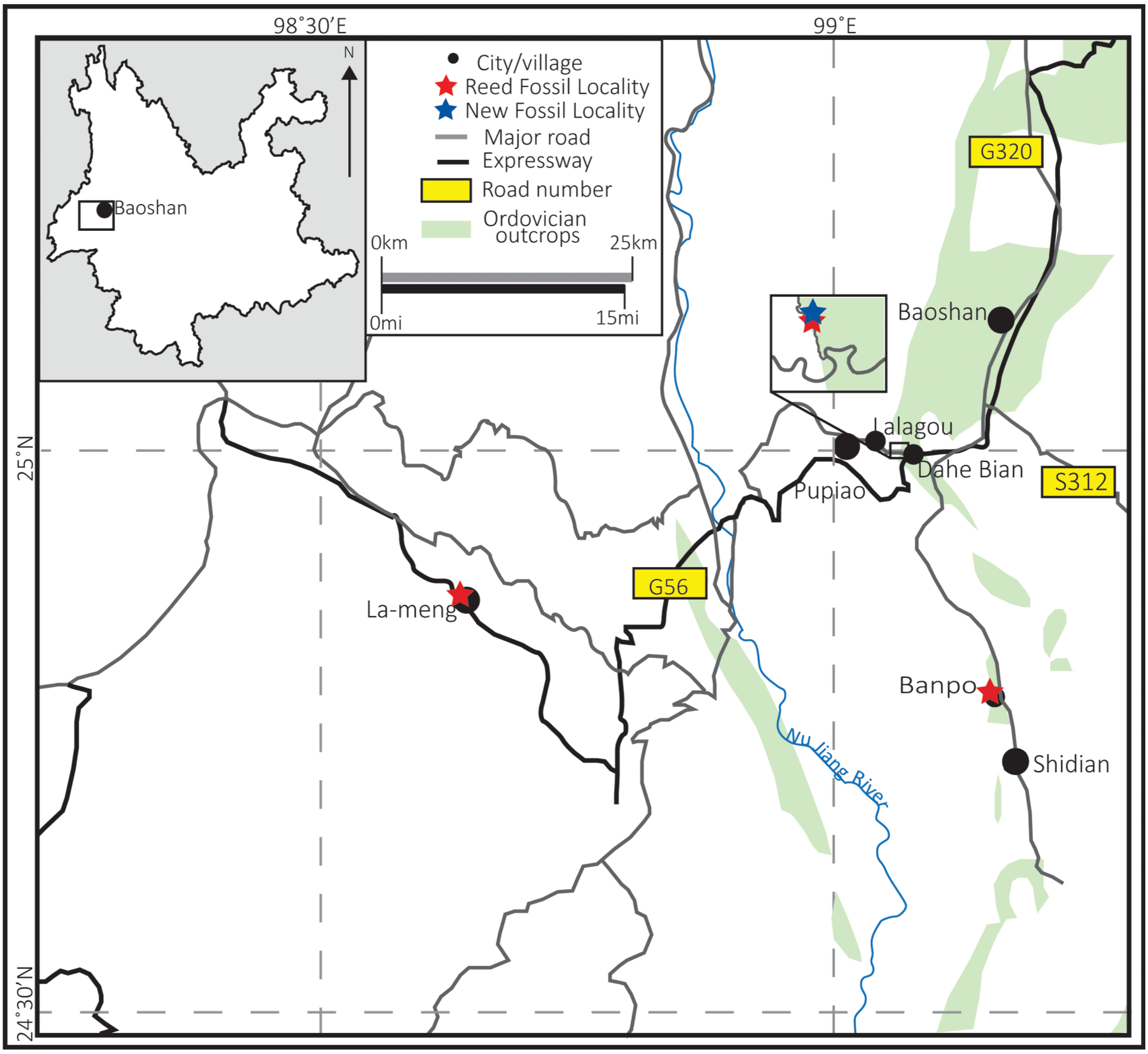

FIGURE 4. Map of the Baoshan area, western Yunnan, China. Areas designated as Ordovician outcrops follow the 1990 Geological Map of Yunnan. Shidian indicates the county government seat rather than the name of the town. See text for further information about the individual fossil localities.

A marked unconformity between the Baoshan Formation and confirmed Ordovician units is locally present in some parts of the Baoshan region. The disconformity is most strongly developed in the south towards Banpo Village, Shidian County (formerly known in English as Shih-tien) (Fig. 4) where Darriwilian strata overlie the Baoshan Formation in an onlapping relationship. The disconformity is less prominent or absent in the area around Baoshan where a full Lower and Middle Ordovician succession has been recorded (Zhang *et al.*, 2014). Zhang *et al.* (2014) attribute the disconformity to an Ordovician topography characterized by an irregular distribution of small islands with deposition only on the flooded platform about these. Huang *et al.* (2012), however, suggest this pattern was caused by regional uplift toward what is now the southwest. Starting in the Darriwilian, both the Shidian and Baoshan areas have similar stratigraphic successions extending into the Llandovery with an upper Katian unconformity that affects both areas (Zhang *et al.,* 2014). Neither the Thai succession nor the Myanmar succession has a similar lower Ordovician unconformity, a further reason why the Baoshan block may not have been fully integrated with Sibumasu at this time (Wernette *et al.,* 2021).

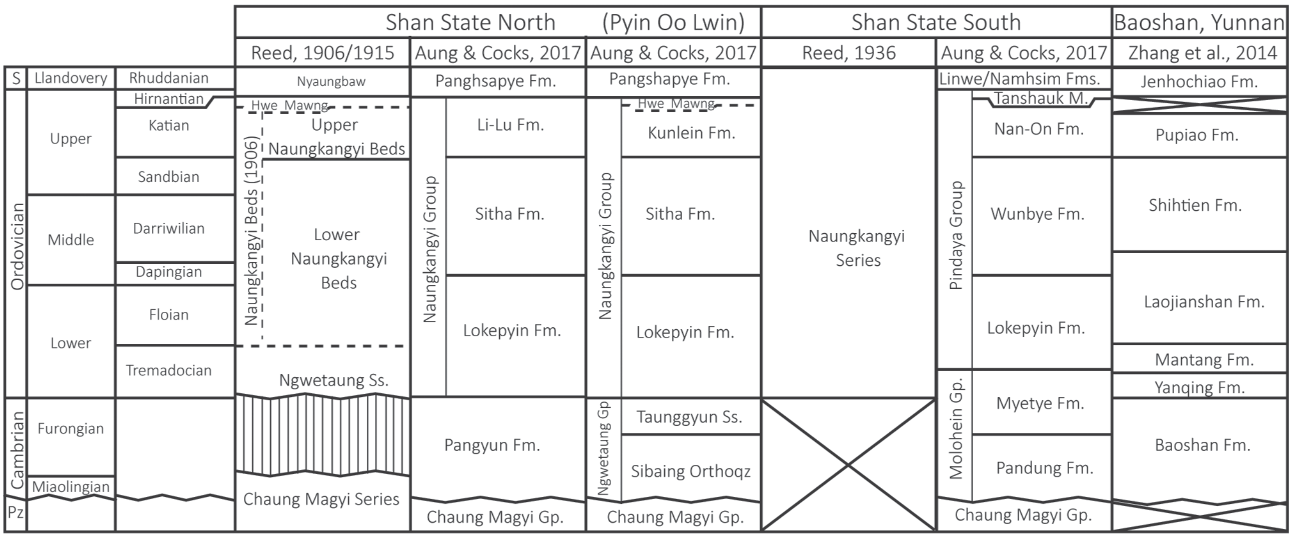

FIGURE 5. Correlation of lithostratigraphic units from Shan State, Myanmar, and the Baoshan Block of western Yunnan.

The Yanqing Formation (lower to middle Tremadocian) is ~400–700 m thick where it occurs near Baoshan but absent in Shidian County near Banpo Village. It is primarily grey fine-grained sandstone. Purple-red shale and flat-nodular argillaceous limestone is intercalated with the sandstone. There are also rare beds of conglomerate and oolitic limestone. The Mantang Formation conformably overlies the Yanqing Formation. It extends to the end of the Tremadocian and is 404–830 m thick where it occurs near Baoshan but is absent near Banpo. It comprises fine-grained quartzarenite and siltstone. The most common sedimentary structures and bedforms are cross-bedding and ripples (Zhang *et al.,* 2014). The Laojianshan Formation (Floian–lower Darriwilian) conformably overlies the Mantang Formation and is 668–800 m thick near Baoshan but only 31 m thick near Liushui in Shidian County. Its lower half is purple-red shales with intercalations of grey-green and yellow clastics of various grains from shale to pebbly sandstone (Zhang *et al.,* 2014). The Shihtien Formation (Darriwilian–Sandbian) conformably overlies the Laojianshan Formation and varies from 52 to 400 m in thickness. The dominant lithology is grey or greyish-green mudstone with intercalations of sandstone, siltstone, and micritic limestone. The specific lithologies of Reed's (1917) collections are in the locality descriptions. Brown (1913) first named this formation, referring to it as the "Shihtien Beds". All of the trilobites that Reed (1917) described come from this formation and especially from the *Didymograptus artus* and *Didymograptus murchisoni* zones, according to the biostratigraphic work of Gertrude Elles (Reed, 1917). More recent work by Zhang *et al.* (2009) revised the graptolite fauna of the Shihtien Formation and confirmed the presence of a diverse assemblage of Darriwilian age.

The Pupiao Formation (Katian) conformably overlies the Shihtien Formation. The thickness varies regionally from 125 m near Shidian to 632 m near Pupiao. Like the underlying Shihtien Formation, the Pupiao Formation consists of argillaceous limestone, excepting the Pingzhang Member which comprises black shale and chert (Zhang *et al.,* 2014). Trilobite fossils occur in the Pupiao Formation; they were not described by Reed but were reported by Zhang (1996). The Jenhochiao Formation (Hirnantian–Telychian) disconformably overlies the Pupiao Formation with the disconformity spanning the upper Katian. Apart from a short interval of claystone at its base, most of the Jenhochiao Formation consists of black shales and chert, similar to the Pingzhang Member of the Pupiao Formation (Zhang *et al.,* 2014).

Localities

The locality information for figured material is based on Reed's (1906, 1915, 1917) descriptions. It was not possible to revisit sites to confirm their locations. Localities were mapped using Google Earth Pro satellite imagery, the northern part of the Shan State map produced by LaTouche (1913), and notes on the Baoshan region in Zhang *et al.* 2014. Northern Shan State site number references refer to LaTouche's (1913) map. Additional assistance in locating towns comes from the GeoNames database (geonames.org). Most coordinates provided should put a fossil collector in the right area but are not precise; to correct for updates to the geodetic longitude of the Madras Observatory, all of Reed's (1915) coordinates were translated 2'27" to the west before further revisions. Many of these localities lie in valleys with extensive agricultural development and may have been destroyed or covered up by natural or human processes since Reed recorded them. English spellings for locality names as Reed reported them are given in brackets after the revised spelling or name (if available); modern use of hyphens and spacing remain inconsistent for some names. Modern taxonomy and lithostratigraphy is given with Reed's original names in brackets. In the account that follows trilobites revised in this paper are listed first, and revisions of brachiopod taxa follow Cocks & Zhan (1998). For the sake of completeness other taxa (e.g. graptolites, mollusks, echinoderms, ostracodes) are listed but these have not yet been revised from the type collections, and the names given are Reed's, as indicated in square brackets.

Northern part of Shan State (Fig. 3).

- Hkawnhkok (Hwe Mawng Beds, uppermost Katian): site 75 (LaTouche); 22°22'00"N, 98°8'38"E. The fossil site is in the stream bed immediately SE of the village.
  - *Mioptychopyge thebawi* (Reed, 1915) [*Ptychopyge thebawi*]; brachiopods *Onniella chaungzonensis* (Reed, 1906) [*Orthis* (*Dalmanella*) *testudinaria shanensis* Reed, 1906]; hyolith [*Hyolithes* (*Orthotheca*) *loczyi*]

- Hpakhi (Hwe Mawng Beds, uppermost Katian): site 79? (LaTouche); 22°12'57"N, 98°20'33"E. LaTouche's map has a fossil site (79) in the Hwe Mawng Beds at these coordinates, but there is no nearby town called Hpakhi. Possibly Hpakhi is a few miles to the south where the legend covers the rest of the map. The fossil site is ~4km WSW of modern day Kattau. There is a different area with a town by the name of Hpakhi on LaTouche's map (22°37'16"N, 98°20'48"E) with a ridge consisting of Hwe Mawng Beds directly to the west; no fossil sites are explicitly mapped near this locality.
  - *Birmanites birmanicus* (Reed, 1915) [*Ogygites birmanicus, Megalaspis* aff. *hyorhina* Schmidt, 1906], *Yanhaoia wynnei* (Reed, 1915) [*Phacops* (*Pterygometopus*) *dagon* var. *wynnei* Reed, 1915]; brachiopod [*Christiania tenuicincta* (M'Coy, 1846)]; hyolith [*Hyolithes* (*Orthotheca*) *loczyi*]; bryozoan [*Ptilodictya* sp.]

- Hwe-hok (Hwe Mawng Beds, uppermost Katian): site 76 (LaTouche); 22°21'46"N, 98°11'01"E. There is no longer a noticeable village center for Hwe-hok. Fossils may be located in the stream banks; when originally mapped the stream made a distinct bend with the fossils found in a small side channel, but that side channel has since captured the main channel.
  - *Lonchodomas shanensis* (Reed. 1915)[*Ampyx rostratus* var. *shanensis*], *Dionide hybrida* Reed, 1915; hyolith [*Hyolithes* (*Orthotheca*) *loczyi*]

- Hwè-mawng (Hwe Mawng Beds, uppermost Katian): site 73 (LaTouche); 21°5'43"N, 97°43'27"E. The fossil site is in the riverbank directly SE of the town.
  - *Birmanites birmanicus* [*Ogygites birmanicus*], *Mioptychopyge thebawi* [*Ptychopyge thebawi, Ptychopyge (Basilicus*) *titanica* Reed, 1915]; *Illaenus* sp. 1 [*Illaenus* aff. *portlocki* Reed, 1915], *Encrinurella insangensis* (Reed, 1906) [*Pliomera* (*Encrinurella*) *insangensis*], *Yanhaoia wynnei* [*Phacops* (*Pterygometopus*) *dagon* var. *wynnei*], [*Phacops* (*Chasmops*?) sp.]; brachiopod indet. plectambonitoid [*Plectambonites sericea*? (Sowerby, 1839)]; hyolith [*Hyolithes* (*Orthotheca*) *loczyi*], [*Platyceras yulei*], [*Trocholites* cf. *ramelei*]

- Hweyawt (Li-Lu Formation [Upper Naungkangyi Beds], Katian): site 95 (LaTouche); 22°29'26"N, 96°55'15"E. Look in the cut bank of the river ~3km NE of Man Sakhansa and south of where the road crosses the river; Hweyawt is limited to a few farming buildings on the east bank of the stream.

    - *Encrinurella insangensis* (Reed, 1906) [*Pliomera insangensis*, *Pliomera* (*Encrinurella*) *insangensis*]; echinoderm [*Caryocrinus*? Sp.]

- Ingsang (Li-Lu Formation [Naungkangyi Beds], Katian): site 93 (LaTouche); 22°35'31"N, 96°57'10"E. The town of Ingsang has become incorporated by Kiohsio South; the fossil locality is ~1.2km SW of the town; fossils are restricted to argillaceous horizons.
    - *Encrinurella insangensis* [*Pliomera insangensis*], [*Encrinurus*? Sp.], *Sphaerocoryphe* sp. (Reed, 1906); brachiopods *Ishimia subdeltoidea* (Reed, 1906) [*Rafinesquina subdeltoidea*], indet. plectambonitoid [*Plectambonites sericea*]

- Kunkaw (Naugkangyi Group [Naungkangyi Beds], Middle-Late Ordovician): site 56 (LaTouche); 22°40'38"N, 97°4'57"E. Kunkaw is ~3.5km SW of Kyengru. The fossil site is ~1.5km NNE of the town, on the north side of Um-oi.
    - *Neseuretinus birmanicus* (Reed, 1906) [*Calymene birmanica*]; brachiopod *Saucrorthis irravadica* (Reed, 1906) [*Orthis irravadica*]

- Kun-lein [Kunlein] (Kunlein Formation [Naungkangyi Beds], Katian): site 89 (LaTouche); 21°53'7"N, 96°23'23"E. Kun-lein is in the hills east of Pyintha and Kyauk-pyo. Fossils are on the ridge to the NW of the town.
    - *Encrinurella insangensis* [*Pliomera insangensis*]; brachiopod *Porambonites* spp. [*Clitambonites* cf. *squamata* von Pahlen, 1877]; echinoderm [*Echinoencrinus* aff. *Senckenbergi*]; bryozoan [*Phylloporina* sp.]

- Ledet (Kunlein Formation [Naungkangyi Beds], Katian): site 82 (LaTouche); 22°3'51"N, 96°24'44"E. Ledet is ~4km WNW of Pin Oo Lwin, a sizeable city whose surrounding areas have been greatly altered since mapped by LaTouche. The fossil site is mapped as being in a stream bed 2-2.5km NW of Ledet, but the local streams have been redirected for irrigation.
    - *Encrinurella insangensis* [*Pliomera insangensis*], [*Remopleurides* sp.] (not cast); brachiopods [*Leptaena*? *ledetensis* Reed, 1906], indet. plectambonitoid [*Plectambonites quinquecostata*], *Saucrorthis irravadica* [*Orthis irravadica*]

- Lilu (1) (Li-Lu Formation [Upper Naungkangyi Beds], Katian): site 103 (LaTouche); 22°55'48"N, 97°18'12"E. Lilu is locatable from the bridge crossing the Myitnge [Nam Tu] River. The fossil site is part way up the ridge immediately to the west of the bridge. LaTouche (1913) shows it to be along a path up the ridge, but this path is now overgrown or too minor to see by satellite.
    - *Ampyx* sp. [*Ampyx* aff. *macullumi*], [*Ptychopyge* sp.], *Parillaenus liluensis* (Reed, 1915) [*Illaenus liluensis*, *Holometopus wimani* Reed, 1915], *Metopolichas* sp. 1 [*Lichas* sp.], *Neseuretinus birmanicus* [*Calymene birmanica*], *Ovalocephalus* sp. [*Calymene* (*Pharostoma*) *liluensis* pars], *Prionocheilus liluensis* [*Calymene* (*Pharostoma*) *liluensis* Reed, 1915 pars], *Hadromeros*? *submitis* (Reed, 1915) [*Cheirurus submitis*], *Encrinurella insangensis* [*Pliomera* (*Encrinurella*) *insangensis*]; brachiopods *Onniella chaungzonensis* [*Orthis* (*Dalmanella*) *testudinaria* var. *shanensis*?], [*Orthis* (*Platystrophia*) *biforata* var. ? (von der Schlotheim, 1820)], *Leangella* (*Leangella*) sp. [*Plectambonites* aff. *llandeiloensis* (Davidson, 1883)]; echinoderms [*Heliocrinus* sp.], [*Carynocrinus* cf. *aurora*?], [*Sphaeronis* sp.]; bryozoa [*Ptilodictya* sp.]; hyolith [*Hyolithes* (*Orthotheca*) *loczyi*], [*Shanina vlastoides*]; annelid [*Turrilepas* sp.]; arthropods [*Aparchites*? Sp.], [*Krausella* sp.], [*Primitia* aff. *mundula*]

- Lilu N. (Li-Lu Foramtion [Upper Naungkangyi Beds], Katian): site 102 (LaTouche); 22°51'37"N, 97°18'55"E. Lilu is locatable from the bridge crossing the Myitnge [Nam Tu] River. The fossil site is on the road connecting Lilu to Man Ping in the North and following about half-way up the ridge on the west bank of the Myitnge River.
    - *Parillaenus liluensis* [*Illaenus liluensis, Holometopus wimani*], *Metopolichas* sp. 1 [*Lichas* sp. 2 Reed, 1915]

- Loi kok (Naungkangyi Group [Lower Naungkangyi Beds], proable Darriwilian): site 106 (LaTouche); 21°58’20”N, 97°47’39”E. Loi kok is a mountain, and the fossil site is near the peak.
  - *Neseuretinus birmanicus* [*Calymene birmanica*]; brachiopod *Bekkerella subcrateroides* (Reed, 1906) [*Orthis subcrateroides*]

- Loi-Pamong (Kunlein Formation [Upper Naungkangyi Beds], Katian): 21°49’31”N, 97°42’34”E. The fossil site is on the west side of a bridge on the slopes of Loi Pamong. Based on Reed’s (1915) coordinates and topography, the bridge was most likely in the drainage valley running east of Loi Pamong towards Hko-mit, although we were not able to locate the bridge.
  - [*Remopleurides* sp.] (not cast); brachiopod [*Porambonites* sp.]

- Makmongshai (Li-Lu Formation [Upper Naungkangy Beds], Katian): site 94 (LaTouche); 22°32’42”N, 96°56’54”E. The village of Makmongshai is not marked on any available maps, but Reed’s coordinates correlate with his description of a cart road crossing the Nam Tung River. What Reed described as a cart road is now Rd 312. The fossils can be found along 312 north of Namsaw.
  - *Metopolichas* sp. 1 [*Lichas*? sp.], *Encrinurella insangensis* [*Pliomera* (*Encrinurella*) *insangensis*]

- Mân-ngai (Li-Lu Formation [Upper Naungkangyi Beds], Katian): site 100 (LaTouche); 22°56’19”N, 97°20’59”E. There is a road from Mân-ngai to Ngaitaö roughly following the mountain ridges; the fossil site is near that road on the west side of the highest peak.
  - *Illaenus* sp. [*Illaenus* sp.], *Metopolichas*? sp. 1 [*Lichas* sp.], *Encrinurella insangensis* [*Pliomera* (*Encrinurella*) *insangensis*], *Dalmanitina*? *dagon* (Reed, 1915) [*Phacops* (*Pterygometopus*) *dagon* Reed, 1915]; brachiopods *Palaeoglossa*? sp. Cockerell, 1911 [*Lingula* cf. *attenuata* Sowerby, 1839], [*Orthis calligramma* var. (Dalman, 1828)], Indet. strophomenids [*Strophomena* sp.], [*Plectambonites* aff. *llandeiloensis*], *Porambonites* sp. [*Porambonites sinuatus* Reed, 1915]; bryozoans [*Rhinidictyia* sp.], [*Ceramopora* sp.], [*Rhopalonaria asiatica*]; hyolith [*Hyolithes* (*Orthotheca*) *irravadicus*], [*Shania vlastoides*], [*Maclurea* sp.]

- Mâ Shio [Man-shio] (Naungkangyi Group [Lower Naungkangyi Beds], Probable Darriwilian): Site 105 (LaTouche); 22°5’32”N, 97°49’25”E. Reed (1915) locates the fossils as on the path to Pinghsai, but the path on LaTouche’s map is either no longer in use or, if still defined, is sufficiently minor not to be visible by satellite. The fossil site is ~2.25 km SE of Mâ Shio on the NE slope of the ridge.
  - *Remopleurides* sp. Reed, 1915[*Remopleurides* sp.], “*Calymene*” *oldhami* (Reed, 1915), [*Calymene oldhami*], *Eccoptochile*? d*ravidicus* (Reed 1915) [*Cheirurus dravidicus* Reed, 1915]; mollusk [*Trocholites*? sp.]

- Mong Ha (1) (Hwe Mawng Beds, uppermost Katian): site 77 (LaTouche); 22°18’48”N, 98°11’50”E. The village of Mong Ha is in the flood plane. The fossil site is on top of a ridge ~1km WSW of the village.
  - *Lonchodomas shanensis* [*Ampyx rostratus* var. *shanensis*], *Birmanites birmanicus* [*Ogygites birmanicus*], *Mioptychopyge thebawi* [*Ptychopyge thebawi*], indet. [*Holometopus orientalis* Reed, 1915], *Encrinurella insangensis* [*Pliomera* (*Encrinurella*) *insangensis*], *Yanhaoia wynnei* [*Phacops* (*Pterygometopus*) *dagon* var. *wynnei*]; brachiopods *Dalmanella*? sp. [*Orthis* (*Dalmanella*) *testudinaria* var. *shanensis*], *Bekkerella subcrateroides* [*Orthis subcrateroides*?], [*Stropheodonta* aff. *corrugatella* Davidson, 1871], [*Christiania tenuicincta*]; hyolith [*Hyolithes* (*Orthotheca*) *loczyi*], [*Hyolithes* (*Orthotheca*) *advena*], [*Shanina vlastoides*]

- Nati (Hwe Mawng Beds, uppermost Katian): site 107? (LaTouche): 21°56’59”N, 97°47’59”E. The village of Nati was in the floodplain ~2.15km NNW of Kyethi [Ke His Mansam], but it has since become farming land. Reed (1915) sites the fossil location as in the stream east of the village but his coordinates place the site in a drainage channel ~1.5km west of the village, a locality confirmed if it is assumed that site 107 on the map is the Nati site. There is a more significant stream to the south and east of where the village used to be.
  - *Niobe* sp. [*Asaphus* cf. *ornatus* Reed, 1915], *Neseuretinus birmanicus* [*Calymene birmanica*]

- Nawa (Naungkangyi Group [Lower Naungkangyi Beds], Probable Darriwilian): site 74 (LaTouche); 22°26’56”N, 98°9’36”E. Nawa is in the floodplain in the bend of the river. The fossil site is on the ridge ~5km N of the town and immediately south of a cluster of buildings on a spur south off the mountain road to Mongyai. This cluster of buildings is unnamed on maps available to us.

o indet. [*Asaphus* cf. *devexus*] (not cast), [*Megalaspis* sp.]; mollusk [*Modiolopsis thebawi*]

- Nawng Yun (Hwe Mawng Beds, uppermost Katian): site 78 (LaTouche); 22°19’59”N, 98°20’35”E. The fossil site is ~2.5km ESE of the town near where the path crosses a stream bed.

o *Mioptychopyge thebawi* [*Ptychopyge thebawi*], *Encrinurella insangensis* [*Pliomera* (*Encrinurella*) *insangensis*], *Yanhaoia wynnei* [*Phacops* (*Pterygometopus*) *dagon* var. *wynnei*], indet. [*Phacops* sp. indet.]

- Pa-hki (Hwe Mong Beds, uppermost Katian): 22°23’4”N, 98°9’2”E. The fossil site is unmarked on LaTouche’s map and not described by Reed (1915) so it can only be said that the fossils are somewhere close to the village, likely in the stream bed on the east side.

o *Neseuretinus birmanicus* [*Calymene birmanica*]; hyolith [*Hyolithes clivei*]

- Panghsapye [Panghsa-pye] (Li-Lu Formaion [Upper Naungkangyi Beds], Katian): site 65 (LaTouche); 22°42’23”N, 97°14’50”E. The fossil site is ~0.75km down the path heading east out of Panghsa-pye.

o *Dalmanitina*? *dagon* [*Phacops* (*Pterygometopus*) *dagon*]; brachiopod *Saucrorthis irravadica* [*Orthis irravadica*?]

- Tâ-Pangtawng [Tapangtawng] (Li-Lu Formaion [Upper Naungkangyi Beds], Katian): site 101 (LaTouche); 22°56’15”N, 97°22’33”E. A bridge over the Myitnge River marks the location of Tâ-Pangtawng. The fossil site is ~1.5km NNW of the bridge along the road to Pangtawng

o indet. [*Harpes* (*Eoharpes*) aff. *flanagani* Reed, 1915] (not cast), *Metopolichas*? sp. 1 [*Lichas* (*Metopolichas*) aff. *Verrucosus* Reed, 1915], *Encrinurella insangensis* [*Pliomera* (*Encrinurella*) *insangensis*]; brachiopods *Plaesiomys* sp. [*Orthis* (*Dinorthis*) *porcata* var. *birmanica* M’Coy, 1842], *Saucrorthis irravadica* [*Orthis irravadica*?], *Leangella* (*Leangella*) sp. [*Plectambonites* aff. *llandeiloensis*?]; echinoderms [*Caryocrinus* cf. *aurora*?], [*Echinoencrinus*? sp.], [*Sphaeronis*? sp.]; bryozoans [*Phylloporina* sp.], [*Caeloclema*? *perplexum*]

Western Yunnan (Fig. 4)

Reed’s collections from Yunnan (Reed, 1917) came from three localities in the Baoshan area. No coordinates or orienting information was given to help locate these localities other than the nearest prominent town. However, we were able to identify two of the original fossil localities based on subsequent work in the area and personal experience at one locality (Pupiao) by NCH. Unlike the northern Shan State collections, in which each locality comprises a single collection, two of the Yunnan localities (Pupiao and Shidian [Shihtien]) encompass five individual collections each. Reed gives horizon information as K 15*###. These three-digit numbers (294–298 for Pupiao and 299–304 for Shidian) are numbers in the collection series and do not indicate stratigraphic height within the section. Some collections are described as coming from the same horizon cropping out in two different spots (e.g. 295 and 296). The lithologic information Reed provided for each collection is reproduced here, and the order replicates Reed’s order, which he referred to as “stratigraphically descending.” However, at Shidian, structural complexities obscure the original succession, and so Reed listed Silurian graptolitic horizons as occurring between Ordovician beds, and the Silurian collection G. Elles assigned to an earlier age is listed above the later one. Nevertheless, Reed’s order is preserved here with the caution that it is stratigraphically inaccurate. His original taxonomy [in brackets] is given for all taxa. Graptolite identifications follow those originally given by G. L. Elles, and are not revised.

- La-mêng (Shihtien Formation, Ordovician): 24°52’N, 98°40’E. We were unable to procure more detailed locality information for La-mêng beyond the general location of the town. La-mêng was the least fossiliferous with the most fragmentary material of Reed’s (1917) three localities. One collection of hard, dark red or purple calcareous shale with a splintery fracture.

o Harpetid indet. [*Harpes* aff. *spasski* Reed 1917] (not cast), asaphid indet. [*Ogygites*? sp.]; brachiopod [*Plectambonites* sp.], [*Orthis*? sp.]; bryozoan [*Pachydictya*? sp.]; mollusk [*Orthoceras*? sp.]; echinoderm [*Heliocrinus* aff. *fiscella*]

- Pupiao (Shihtien Formation, Darriwilian, *Didymograptus murchisoni* Zone): 25°00’18”N, 99°03’44”E. On highway G320 between Dahe Bian and Lalagou, a prominent dirt road runs north up the mountain. Loczy (1898) described some fossils from near Pupiao, but it is unclear whether it is the same Pupiao locality. The Shihtien Formation’s fossils mostly occur in hard, brownish-yellow or green massive mudstones with a subconchoidal fracture pattern. Other lithologies include a weakly fossiliferous reddish shaly mudstone that lacks conchoidal fracture and a weakly and fragmented fossiliferous dark-grey sandy “crystalline limestone”. The Pupiao Formation also crops out on this hill, and the new material presented herein (Figs 15.24) is from a bank along the track partway up the hill at 25˚00’17”N, 99˚03’44”E, 1830 m altitude. The deforested slope just east of Dahe Bian exposes Cambrian outcrops of the Baoshan Formation.

o K 15*298: reddish-yellow soft and occasionally sandy slates.

▪ *Pliomerina martellii* (Reed, 1917) [*Pliomera martellii* Reed, 1917]; brachiopods [*Orthis praetor* Reed, 1917], [*Orthis*? sp.]; ostracode [*Primitia* sp.]; echinoderm [*Echinoencrinus* sp.]

o K 15*297: hard nodular limestone with shaly laminae.

▪ Echinoderm [*Caryocrinus* cf. *turbo*]

o K 15*295: very fossiliferous, fine-grained greenish-grey hardened shales.

▪ Remopleuridid gen. et sp. indet. [*Remopleurides* aff. *latus* Reed, 1917], *Birmanites yunnanensis* (Reed, 1917),[*Ogygites yunnanensis* Reed, 1917], *Illaenus* sp. 3 [*Illaenus* cf. *esmarki* Reed, 1917], *Nileus* sp. [*Nileus armadillo* Reed, 1917], *Reedocalymene unicornis* (Reed, 1917) [*Calymene unicornis* Reed, 1917]; brachiopods [*Orthis praetor*], [*Orthis* sp.], [*Streptis* sp.], [*Porambonites* sp.]; graptolites [*Didymograptus murchisoni*], [*Didymograptus murchisoni* var. *geminus*], [*Didymograptus indentus*], [*Climacograptus* cf. *scharenbergi*]; echinoderm [*Echinoencrinus* sp.]; bryozoan [*Pachydictya*? sp.]; mollusks [*Ctenodonta* sp.], [*Raphistoma* sp.], hyolith [*Hyolithes* cf. *clivei*], [*Hyolithes* cf. *loczyi*]

o K 15*296: very fossiliferous, fine-grained greenish-grey hardened shales; down hill from K 15*295.

▪ *Phorocephala mansuyi* (Reed, 1917) [*Bathyurus mansuyi* Reed, 1917], *Pliomerina martellii* [*Pliomera martelli*], *Metopolichas* sp. 1 [*Lichas* aff. *verrucosus* Reed 1917]; brachiopod [*Orthis praetor*]; mollusk [*Orthoceras* sp.]; echinoderm [*Echinoencrinus* sp.]; bryozoan [*Pachydictya*? sp.]

o K 15*294: fossils from several horizons of slate and hardened shale.

▪ *Illaenus* sp. [*Illaenus* cf. *tauricornis* Reed, 1917], *Nileus* sp. [*Nileus armadillo*], [*Calymene* sp.], *Pliomerina martelli* [*Pliomera martellii*]; ostracode [*Primitia* sp.]; graptolites [*Didymograptus murchisoni* var. *geminus*], [*Didymograptus indentus*]; echinoderms [*Echinosphaera* cf. *aurantium*], [*Protocrinus*? sp.], [*Heliocrinus*? sp.]; brachiopod [*Orthis praetor*]; hyolith [*Hyolithes* sp.]

- Shidian [Shih-tien]: 24°46’25”N, 99° 8’55”E. The Shihtien collections were likely made in the hillside surrounding Banpo Village. The roadcut near this village has since become the type section for the Shihtien Formation (Zhang, 1996). This hillside contains outcrops of both the Shihtien Formation and the Jenhochiao Formation. The dominant lithology is a dark greyish argillaceous micritic limestone. Other lithologies include a soft, earthy, red calcareous mudstone, a pale-grey massive “crystalline limestone”, a dark greyish-green massive “crystalline limestone”, and a pale pinkish or greenish-yellow calcareous mudstone.

o K 15*300 (Shihtien Formation, Darriwilian, *Didymograptus artus* Zone?): Red earthy limestones and dark shaley limestones.

▪ [*Illaenus* sp.] (not cast); echinoderm [*Pyrocystis*? o*rientalis*]; nautiloid mollusks [*Endoceras* aff. *reinhardi*], [*Orthoceras regulare*], [*Orthoceras* cf. *scabridum*], [*Cyrtoceras* sp.], [*Spyroceras*? sp.]

o K 15*301 (Jenhochiao Formation, Llandovery, *Orthograptus vesiculosus* to *Monogratus gregarius* zone): Black, fissile shales.

▪ Graptolites [*Monograptus incommodus*], [*Monograptus regularis*], [*Monograptus tenuis*?], [*Climacograptus toernquisti*], [*Climacograptus rectangularis*], [*Climacograptus* sp.], [*Mesograptus modestus*]

- K 15*302 (Shihtien Formation, Darriwilian, *Didymograptus artus* Zone?): Red marls and thin, lenticular limestone beds.
  - *Illaenus caecoides* Reed, 1917; echinoderms [*Ovocystis mansuyi*], [*Sphaeronis lobiferus*], [*Sphaeronis shihtiensis*], [*Heliocrinus fiscella*], [*Carycocystis bicompressa*], [*Pyrocystis*? *orientalis*]; mollusks [*Holopea* (*Haplospira*?) sp.], [*Bellerophon* (*Sinuites*) cf. *rugulosus*], [*Orthoceras regulare*], [*Orthoceras* cf. *kinnekullense*], [*Orthoceras* sp.], [*Orthoceras regulare*], [*Trocholites yunnanensis*], [*Trocholites* aff. *macromphalus*], [*Lituites* sp.], [*Tarphyceras* sp.]

- K 15*304a (Shihtien Formation, Darriwilian, *Didymograptus artus* Zone?): Weathered outcrops of various beds on lower slopes of the hill. This collection consists of two subcollections. This collection (a) consists of Ordovician fauna; the other (b) consists of sandy shales with Silurian graptolites. This order is as in Reed, but the a and b are new additions herein.
  - [*Illaenus* aff. *oblongatus*] (not cast); echinoderms[*Sinocystis loczyi*], [*Sinocystis yunnanensis*], [*Ovocystis mansuyi*], [*Eucystis* cf. *raripunctata*], [*Echinosphaera asiatica*], [*Echinosphaera sinensis*], [*Heliocrinus fiscella*], [*Heliocrinus subovalis*], [*Heliocrinus* cf. *balticus*], [*Camarocrinus asiaticus*], [*Hemipronites* sp.], [*Rafinesquina*? sp.]; mollusks[*Endoceras wahlenbergi*], [*Endoceras* cf. *cancellatum*], [*Cameroceras*? sp.]

- K 15*303 (Shihtien Formation, Darriwilian, *Didymograptus artus* Zone?): Black massive shales with concretions.
  - Asaphid indet. [*Asaphus* aff. *expansus*], *Illaenus* sp. 2 [*Illaenus* aff. *schmidti* Reed, 1917], *Metopolichas* sp. 2 [*Lichas celorhin* var. *coniceps* Reed, 1917]; brachiopods [*Philhedra sinensis* Reed, 1917], [*Hemipronites giraldi* var. nov. *yunnanensis*], [*Hemipronites* sp.], [*Orthis praetor* Reed, 1917]; mollusks [*Endoceras* sp.], [*Orthoceras deprati*], [*Jovellania* sp.]

- K 15*304b (Jenhochiao Formation, Llandovery, *Monogratus sedgwickii* Zone): Sandy graptolitic shales. See K 15*304a for further locality notes.
  - Graptolites [*Monograptus sedgwicki*], [*Monograptus lobiferus*], [*Monograptus tenuis*], [*Monograptus leptotheca*], [*Monograptus atavus*], [*Monograptus jaculum*], [*Monograptus concinnus*], [*Monograptus gemmatus*], [*Glyptograptus serratus*], [*Glyptograptus incertus*], [*Climacograptus scalaris*], [*Glyptograptus toernquisti*], [*Gladiograptus perlatus*], [*Mesograptus magnus*]

Palaeobiogeographical comments concerning Reed's material

The collections on which Reed based his descriptions include a modest number of trilobite species, although there is reason to suppose that further collecting from the type localities would readily enhance their numbers. Their main importance resides in the types, particularly type species of genera, but they also have palaeobiogeographic implications. The two principal assemblages are Middle Ordovician (Darriwilian) and Upper Ordovician (Katian) in age. They are similar in their biogeographic signal.

The trilobites of western Yunnan and the northern part of Shan State can be divided into two broad categories: widespread genera of limited palaeogeographical import; and genera whose distribution patterns are related to the disposition of the Ordovician palaeocontinents (recent summary in Torsvik & Cocks, 2017). The faunas are not sufficiently diverse to contribute to an understanding of the complexities of the Ordovician central Asian terranes and the Kazakh archipelago (Popov & Cocks, 2017). Comparisons are mostly at generic level, partly because the imperfect preservation of Reed's material makes for difficulties in assessment, but also because there are few taxonomic studies that attempt to assess a particular group rather than a whole fauna. An exception is Turvey (2005).

Middle Ordovician, Darriwilian strata from Western Yunnan, Baoshan region, contain the widely distributed taxa *Phorocephala*, *Nileus*, and *Metopolichas* Gürich, 1901. Similarly widespread taxa from the Katian of the northern part of the Shan State include *Illaenus* Dalman, 1827, *Dionide*, *Prionocheilus*, *Lonchodomas*, *Sphaerocoryphe* Angelin, 1854, *Eccoptochile* Hawle & Corda, 1847, *Hadromeros* Lane, 1971 and *Metopolichas*. Such broadly distributed taxa are recorded from palaeocontinents at low palaeolatitudes—including Laurentia and the Siberian plates, for example, as well as Gondwana. In some analyses *Dionide* has been associated with more offshore biofacies (e.g. Ebbestad & Fortey, 2019), although this is not invariable; *Phorocephala* is a telephinid trilobite that may have been pelagic. None of these genera is biogeographically critical.

The Family Asaphidae has long been recognised as important in delimiting biogeographic "provinces" since Whittington (1963) pointed out the endemicity of members of that family over what is now known as the Ordovician Baltica palaeocontinent. Many additional endemic Baltic taxa were named by Balashova (1976). A different suite of asaphid trilobite genera characterised the Ordovician of Laurentia (e.g. Amati, 2014), some of which extend into Siberia. The asaphids have proved reliable geographic indicators. Yet further distinctive asaphids appear to characterise the northern (present geography) margins of Gondwana. In the systematic section we discuss in detail the Subfamily Birmanitinae, since the genus *Birmanites* is based upon Reed's specimens, however imperfect. It is a distinctive trilobite, very closely related to *Ogygites* Tromelin & Lebesconte, 1876 /*Nobiliasaphus* Přibyl and Vaněk, 1965 (detailed discussion below); the type species of the latter is from eastern Gondwana, and the genus is known from Morocco, close to the Ordovician pole. *Birmanites* species are known from taxa that are better preserved than the type species coming from many localities in southwest China (Lu, 1975; Zhou & Zhen, 2008), the Tarim Basin (Zhou *et al.,* 2014), Iran and Kazakhstan (Ghobadi Pour *et al.*, 2011) and in an eastern Gondwana terrane from Wales (Hughes, 1979). *Ogygites/Nobiliasaphus* has a geographic range that overlaps that of *Birmanites*. A varied group of species of the former is described from the Iberian Peninsula (Rabáno, 1989) and it extends eastwards through Sardinia as far as the Pamir Range (Balashova, 1966)—but not, apparently, into China. *Birmanites birmanicus*, the type species from northern part of Shan State, is clearly different from an older species, *B. yunnanensis* Reed, 1917*,* in the Shihtien Formation that is widely reported in Yunnan Province, also in Dali (Simao block), and on the South China block itself. In terms of preferred biofacies, *Birmanites* spans a range of shelf habitats but Zhou *et al.* (2014, fig. 6) indicate a preference for deeper shelf environments with a maximum abundance in what they term "inner deep outer shelf". Since *Birmanites* is a large trilobite with a thin cuticle it is reasonable to assume that this trilobite avoided shallow and turbulent habitats. We consider below that the asaphid genus *Mioptychopyge* is also likely to be a member of the Birmanitinae, and several species attributed to this genus are also known from Dali and the South China plate (Turvey, 2007). A single fragmentary pygidium from northern part of Shan State which may possibly belong to *Dolerobasilicu*s Kobayashi, 1934 provides a tenuous link with South Korea.

The calymenid subfamily Reedocalymeninae is a well-supported clade within Calymenidae that has the advantage of a thorough revision by Turvey (2005). Like Birmanitinae this group is confined to the Ordovician of Gondwana and its margins. The type species of *Reedocalymene, R. unicornis* (Reed, 1917), is from the Yunnan collection and the material is now unfortunately not in good condition. Nonetheless, Lu (1975) described related taxa from south-west China that are doubtless congeneric and provide a full picture of the genus. It has not yet been found in western Gondwana, although comparable forms are known in the Himalaya (Myrow *et al.,* in press). *Neseuretinus* is a close relative of the most widespread of the Reedocalymeninae, *Neseuretus*, which has a distribution that encircles the Gondwana continent but does not extend beyond it, other than into Avalonia. The distribution of *Neseuretinus* itself was summarised by Turvey (2005): the type species was from Turkey and the distribution extended eastwards to Myanmar and Yunnan (illustrated herein) by way of Afghanistan (Wolfart, 1970) and the Tien Shan (Kolobova *in* Sokolov & Yolkin, 1978); a subsequent occurrence has been reported in Iran (Ghobadi Pour & Popov, 2009). RAF is studying an early species of the genus from the Darriwilian of the Sultanate of Oman. Again, this is a peri-Gondwana distribution extending from the Middle East to China. The genus is not known from any other palaeocontinent.

The same pattern is repeated for other genera represented in the Reed collections. *Ovalocephalus* is a distinctive taxon with a very wide distribution after early Ordovician occurrences of the genus apparently confined to southern China (Zhou *et al*., 2010). Its subsequent range, from southern Thailand (Fortey, 1997), Kazakhstan, Iran (Ghobadi Pour & Popov, 2009), Sardinia (Hammann & Leone, 2007), and the Iberian Peninsula (Hammann, 1992), again tracks the Gondwana periphery. If we are correct in assigning Reed's *Illaenus liluensis* to *Parillaenus*, that genus, too, tracks the Gondwana margin from southern China (Zhou *et al.,* 1984) to central Spain (Hammann, 1992), with the addition of Baltica.

Finally, there is a small group of genera that are typical of southern China, and with an easterly distribution appropriate to low palaeolatitudes on most Ordovician continental reconstructions. This 'provincial' distribution was recognised already by Webby (1971) and Whittington & Hughes (1972). *Pliomerina* is a distinctive pliomerid genus; it includes Reed's type species from western Yunnan and a distribution embracing China, Australia, and some Kazakh terranes, as Webby (1971) noted. *Encrinurella*, with a Reed type species from northern pat of Shan State, has a reported occurrence in Thailand (Fortey & Cocks, 1998) as well as records in southern China and Australia (Whittington & Hughes, 1972). Additionally, Zhang *et al.* (2014, fig. 5.41A) illustrated *Sinocybele* Sheng, 1974 from the Shihtien Formation, which also has an Australia/South China/Kazakh distribution (Edgecombe & Webby, 2006). We record below the genus *Yanhaoia* Zhou, Yuan & Zhou, 1988 also, another South China/Tarim endemic, although with the caveat that the type species is not adequately known.

There can be no question that the palaeogeographically significant elements in the Reed collections are related to the Ordovician Gondwana continent. Most genera—or even subfamilies—are endemic to that region. Within the marginal marine habitats several genera are surprisingly widespread around Gondwana, extending from near the palaeoequator to high palaeolatitudes. They may include deeper shelf inhabitants less affected by near-shore constraints of temperature and turbulence. There is no reason to doubt a particular connection between the northern part of Shan State and southern Chinese shelf faunas, and a few genera among them are otherwise palaeotropical. This affinity seems to apply along the Malay Peninsula as far as southern Thailand, where the diverse fauna of the Pa Kae Formation is almost identical to that of the Pagoda Limestone (Fortey, 1997; Cocks *et al.*, 2005; Zhou *et al.*, 2016).

Systematics

Remarks. Reed provided thorough general descriptions of the species he erected, including dimensions of type specimens. It will not be necessary to repeat all details in this revision. Our descriptive remarks often relate to features not noted by Reed, requiring amplification, or pertaining to the attempted retrodeformation of distorted specimens. There has been much to add to update the taxonomy since the early part of the twentieth century. In the account below, modern generic names are used and Reed's names will be found in the synonymy list. Systematic order largely follows the Treatise on Invertebrate Paleontology Part O (Revised) (Whittington *et al.*, 1997) with additions from Adrain (2011). Almost all the material figured are latex moulds made from specimens in the GSI collection or their back-casts in polyurethane at the Natural History Museum, London. Additional specimens held in the Cincinnati Museum Center (CMC IP). Although we were able to cast most of the Reed specimens, some were too fragile or decayed to cast, such as the agnostid and harpetid in Reed (1915), and these are not treated below; they do not have taxonomic significance.

Family Asaphidae Salter, 1864

Discussion. Three of Reed's asaphid species redescribed below are of systematic importance, and worth assessing in detail. A few of Reed's asaphid pygidial fragments were not cast.

Subfamily Birmanitinae Kobayashi, 1960

Discussion. *Birmanites* Sheng, 1934, with type species *Ogygites birmanicus* Reed, 1915, was originally described as an asaphid, but was placed in a separate family Birmanitidae by Kobayashi (1960, p. 254) and in Dikelokephalinidae in the 1959 *Treatise on Invertebrate Paleontology* (Harrington *et al. in* Moore, 1959). Lu (1975, p. 319) regarded *Birmanites* as no more than an unusually flat asaphid, with a relatively small glabella, an opinion with which we concur; the taxon Birmanitidae has disappeared from the literature. It is, however, still available as a subfamily name within Asaphidae. Division of Asaphidae into subfamilies is itself contentious; a relatively conservative approach was used by Jaanusson (*in* Moore, 1959), who employed seven subfamilies. The opposite approach was that of Balashova (1976) who elevated Asaphidae to subordinal level and divided the group into numerous families and subfamilies. Balashova nominated subfamilies centred on well-known Baltic endemic genera such as *Megistaspis* Jaanuson, 1956*, Pseudoasaphus* Schmidt, 1901 and *Ptychopyge* Angelin, 1854, to each of which she consigned a number of her own, finely divided genera. This is not an appropriate place to review this work of prolific taxonomic 'splitting', although the majority of Balashova's taxa are confined to the Ordovician Baltic Shield, and her scheme has not been widely adopted. However, Balashova's (1976) Subfamily Nobiliasaphinae (placed in Family Pseudoasaphidae Balashova, 1969, by Balashova [1976]) includes the genera *Opsimasaphus* Kielan, 1960, and *Nobiliasaphus* Přibyl & Vaněk, 1965, both of which are closely similar to *Birmanites*, and must surely be included within the same subfamily, whatever taxonomy is eventually adopted. The name Birmanitinae Kobayashi, 1960 is the older name for this group even though it was not recognised by Balashova (1976).

An objective appraisal of asaphid trilobites is overdue. An unpublished PhD thesis by Mark Bell (2009) under the supervision of RAF attempted a cladistic analysis of Asaphidae. One group that comprised a clade with moderate support included *Birmanites,* and the name Birmanitinae is appropriate for it. The most important characters uniting the group are displayed by the hypostome, which has a characteristic rounded to oval middle body with prominent maculae at the rear, and a broad, U-shaped fork, and hypostome widest at, or in front of the maculae. The characteristic hypostome is illustrated by a specimen from the type series of *Birmanites birmanicus* figured herein (Fig. 6.1) and an illustrative reconstruction (Fig. 7.b), and by the Barrandian lectotype (selected Kielan, 1960, p. 76) of *Nobiliasaphus nobilis* (see Horný & Bastl, 1970, pl. 6 fig. 1; Rabáno, 1989, pl. 3, fig. 6; also, Hughes, 1979, fig. 11 for a similar hypostome, and Hammann & Leone 1997, pl. 6, fig. 3 and Turvey, 2007 for further examples). Dorsal characters in the group are variable with regard to width of pleural areas, preglabellar field, dorsal effacement and the like, but a glabella with an inflated, often pyriform frontal lobe and with a pair of posteriorly inwardly sloping, and often deepened axial/glabellar furrows which constrict a narrow median glabellar lobe in front of the occipital ring, is also typical. Where known, the medial tubercle is immediately pre-occipital (*Birmanites*—see Lu, 1975, pl. 8, fig. 8), and the dorsal facial sutures run at, or at least very close to the anterior margin before they meet medially. A distinctive genus from central Australia, *Norasaphus* Fortey & Shergold, 1984, which includes the only tuberculate asaphids, also belongs within the same group, showing similar hypostome construction and glabella furrows, even though it is much more convex and less flattened peripherally than *Birmanites*. Turvey (2007) added further Chinese taxa to this group. *Nobiliasaphus* is distinguished from *Birmanites* in having a curious structure of the pygidial axis, with chevron-like medial backward deflections of the ring furrows, the ring itself bisected transversely by fainter extra furrows and ridges of similar form.

This asaphid group is peri-Gondwanan, with scattered occurrences from France, Iberian Peninsula and Wales eastwards to southwest China. The genus *Pamirotetchites* Balashova, 1966, from the Pamirs in central Asia is a junior synonym of *Nobiliasaphus* as Balashova (1976, p. 59) realised, and displays the same distinctive pygidial structure as *N. nobilis* (Barrande) (see also *Opsimasaphus pseudodawanicus* Lu, 1975, *in* Turvey, 2007). *Norasaphus* is so far confined to Australia, while *Nobiliasaphus* does not extend east of the Pamirs. *Birmanites* is more widespread. Whether this group should be included within a more inclusive clade based on *Pseudoasaphus* (as claimed by Balashova, 1976) is uncertain. Many genera of Asaphidae are known to be endemic to Baltica, such as those placed in Megistaspidinae by Balashova (1976), and *Pseudoasaphus* may be no exception. *Pseudoasaphus* spp. have anterior branches of the facial sutures which cross the fontal area well away from the anterior cephalic margin before meeting in an acute point (e.g. Jaanusson, 1953, pl. 4, fig. 3), and hypostomes attributed to related genera are relatively long and narrow, with more extended 'forks' subtending an almost v-shaped outline (Balashova, 1976, pl. 3).

Birmanites Sheng, 1934

Type species. *Ogygites birmanicus* Reed, 1915. 'Hwe Mawng Beds', northern Shan State, Myanmar, original designation.

Diagnosis. Lu's (1975, p. 318–9) diagnosis is still largely appropriate. It should be modified to include the inverted U shape of the wide hypostomal fork, and to emphasise that the pygidial ring furrows are transverse, rather than chevron–shaped. Despite the thin cuticle, the terrace ridges on the pygidial doublure are particularly strong. Only the best-preserved material shows a pointed junction of the facial sutures on the midline. In most flattened material the sutures appear to run nearly marginally over their anterior course.

Discussion. *Birmanites birmanicus* was originally referred by Reed (1915) to the genus *Ogygites* Tromelin & Lebesconte, 1876 (type species *Ogygia desmaresti* Brongniart *in* Brongniart & Desmarest 1822), and we are therefore obliged to discuss both genera here. The type material of the type species of *Ogygites* is both distorted and incomplete, and a very detailed discussion of it by Rabáno (1989. p. 76–82) concluded with placing *Ogygites* 'Incertae subfamiliae" within Asaphidae. She regarded the clarification of the identity of *Ogygites* as beyond resolution and recommended restricting its usage to the distorted holotype. Rabáno (1989) was unaware of a forthcoming revision of *O. desmaresti* from the type area of Angers by Pillet (1990), who attributed much additional material to the same species. Although it is distorted, much of it is articulated, and if Pillet is correct in attributing his material to *O. desmaresti*, as is likely, it is clear that the type species of *Ogygites* shares its principal features with both *Birmanites* and *Nobiliasaphus*. The pygidium is not seen on the type material, but several specimens figured by Pillet (e.g. 1990, pl. 15) prove the presence of numerous backwardly directed chevron-shaped ridges/furrows on the long and narrow pygidial axis that are clearly present also on the type specimens of *Nobiliasaphus nobilis* (Barrande) and *Pamirotechites pamiricus* Balashova, but not on *Birmanites birmanicus* or other oriental species of *Birmanites*. This is such an unusual character that in our view it is likely a synapomorphy of species sharing it, and constitutes the defining character of *Nobiliasaphus*/*Ogygites*. For example, Rabáno (1989) illustrated several species from Spain showing this feature, and Hammann & Leone (1997) illustrated others from Sardinia. One of Rabáno's species, *N. hammanni*, has a posterior pygidial spine, which is not considered generically significant. However unsatisfactory its type material, it is likely that *Ogygites* is the senior name for this clade. If *Birmanites* is restricted to species with transverse pygidial ring furrows then some species may be better placed in *Birmanites* rather than *Nobiliasaphus*; for example, *Nobiliasaphus powysi* Hughes, 1979, from the Ordovician of the Builth Inlier, Wales. The range of *Nobiliasaphus*/*Ogygites* does not extend as far to the east (present geography) over Ordovician Gondwana as does that of *Birmanites*. Finally, *Opsimasaphus* Kielan, 1960 (type species *O. jaanussoni* Kielan, 1960) differs from *Birmanites* in having a relatively short (sag.) pygidium—the structure of the pygidial axis (with the exception of Chinese *O. pseudodawanicus*, see Turvey 2007) is similar to that of *Birmanites* rather than *Nobiliasaphus*/*Ogygites*, and the cephalic features seem to us identical to those of *Birmanites*. Kielan (1960, p. 75-77) gave a detailed account of *Opsimasaphus* in relation to what would now be called *Nobiliasaphus* Přibyl and Vaněk, 1965, but did not bring *Birmanites* into the discussion, possibly because when she was writing this genus was still regarded as a dikelokephalinid. Chugaeva (1958) described *Ogygites almatyensis* from Kazakhstan, which would be better placed in *Birmanites* on the criteria given here. It is possible that *Opsimasaphus* is a subjective junior synonym of *Birmanites,* as discussed by Zhou & Dean (1986) and Romano & Owen (1993), while *Opsimasaphus* was retained by Turvey (2007, p. 366).

Birmanites birmanicus **(Reed, 1915)**

Figs 6, 7.

1915 *Ogygites birmanicus* Reed, p. 30-32, pl. 5, figs 15–18; pl. 6, figs 1–4.
1915 *Megalaspis* aff. *Hyorhina* Leuchtenberg *in* Schmidt, 1906, Reed, p. 35–36, pl. 7, fig. 2.

Material Holotype (selected Reed, 1915, p.32): incomplete cephalon and first few thoracic segments from the Hwe Mawng Beds at Hwe Mawng, Fig. 6.2, (Reed, 1915, pl. 6, figs 1–2), GSI 11522. Paratype material: incomplete dorsal exoskeleton from Hpakhi, Fig. 6.6 (Reed, 1915, pl. 5, figs 15–16), GSI 11518; incomplete dorsal exoskeleton from Hpakhi, Fig. 6.3 (Reed, 1915, pl. 6, fig. 3), GSI 11523; incomplete dorsal exoskeleton from Hwe Mawng, Fig. 6.4 (Reed, 1915, pl. 6, fig. 4), GSI 11524; hypostome in life position from Hwe Mawng, Fig. 6.1 (Reed, 1915, pl. 5, fig. 17), GSI 11519; cranidium from Hwe Mawng (Reed 1915, pl. 5, fig. 18), GSI 11520. Additional material: cranidium from Hpakhi, Fig. 6.5 (Reed, 1915, pl. 7, fig. 2), GSI 11534. All from Hwe Mawng Beds (uppermost Katian) at Hapakhi or Hwe Mawng, northern Shan State.

Descriptive remarks. Reed (1915) recognised distortion in the specimen figured here as Fig. 6.4a, but did not seem to acknowledge distortion more generally, regarding the variation in relative widths from one specimen to another as variation within the species. The incomplete dorsal shield (Fig. 6.6 herein) does not show evidence of distortion and compares in its proportions with subsequently described species. However, the holotype (Fig. 6.2a) is very likely transversely extended. An attempt at its retrodeformation restoring to similar proportions to the undistorted specimen (Fig. 6.2b) produces a more plausible, semicircular outline for the eyes. The glabella occupies very slightly more than half the cephalic length (sag.) in both. A large cranidium in Reed's illustrations may be lengthened (1915, pl. 7, fig.2), but we regard it as probably also belonging to *B. birmanicus*, rather than '*Megalaspis*'. We were not able successfully to cast the original cranidium of Reed's pl. 5, fig. 18, which shows similar extension, and this extension may apply also to the original of Fig. 6.3. The preservation of the glabella is not good, but Reed correctly described the pyriform frontal lobe extending far back, with a single pair of glabellar furrows defining a weak triangular lobe adjacent to the palpebral area, best shown on the left-hand side of Fig. 6.6. The cephalic doublure extends almost to the eye, and most specimens showing it are composite, i.e. the impression of the strong, widely spaced terrace ridges on the doublure is marked on the dorsal surface. Not all material displays the weak

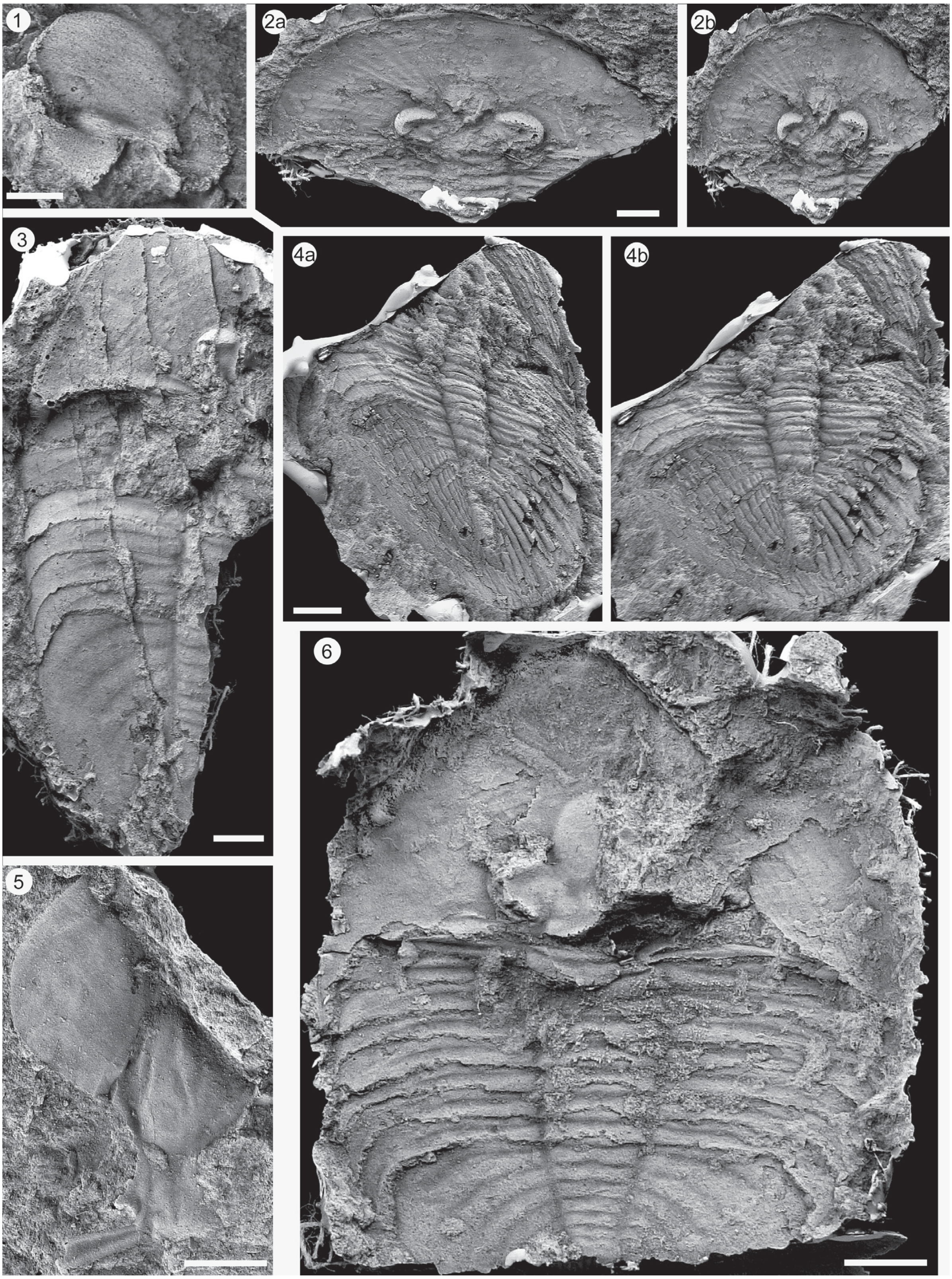

FIGURE 6. *Birmanites birmanicus* (Reed) from the Hwe Mawng Beds (uppermost Katian), northern Shan State, Myanmar. 1. Hypostome (original of Reed 1915, pl. 5, fig. 17), GSI 11519, Hwe Mawng. 2a, b. Cephalon (original of Reed 1915, pl. 6, fig. 2), GSI 11522, Hwe Mawng, original and retrodeformation. 3. Partial specimen (original of Reed 1915, pl. 6, fig. 3), GSI 11523, Hpakhi. 4a, b. Pygidium (original of Reed 1915, pl. 6, fig. 4), GSI 11524, Hwe Mawng, original and retrodeformation. 5. Cranidium (original of Reed 1915, pl. 7, fig. 2), GSI 11534, Hpakhi. 6. Partial specimen (original of Reed 1915, pl. 5, figs 15,16), GSI 11518, Hpakhi. Scale bars = 2 mm for 1; = 5 mm for 2–6.

'radiating folds' (Reed, 1915, p. 31) crossing the free cheeks and preglabellar field and it may be that the flattening also exaggerates them. Reed noted up to 40 such folds, but there are about half that number. The hypostome (Fig. 6.1) is slightly twisted and cannot really be retrodeformed; it does show the elongate oval middle body and wide fork we regard as typical for Birmanitinae. The retrodeformed Fig. 6.4b shows the similarly wide pygidial doublure approaching the axis, with about eight very strong terrace ridges shallower exteriorly and converging around the tip of the axis. This pygidium shows up to eight ribs; a gentle backward curvature is seen on the least distorted specimens, which is one reason to suspect that the original of Fig. 6.3 has been stretched lengthwise to produce steeper curvature and a deeper pygidial margin. Seven axial rings are visible on Fig. 6.6, which also shows the transverse ring furrows slightly shallowing medially.

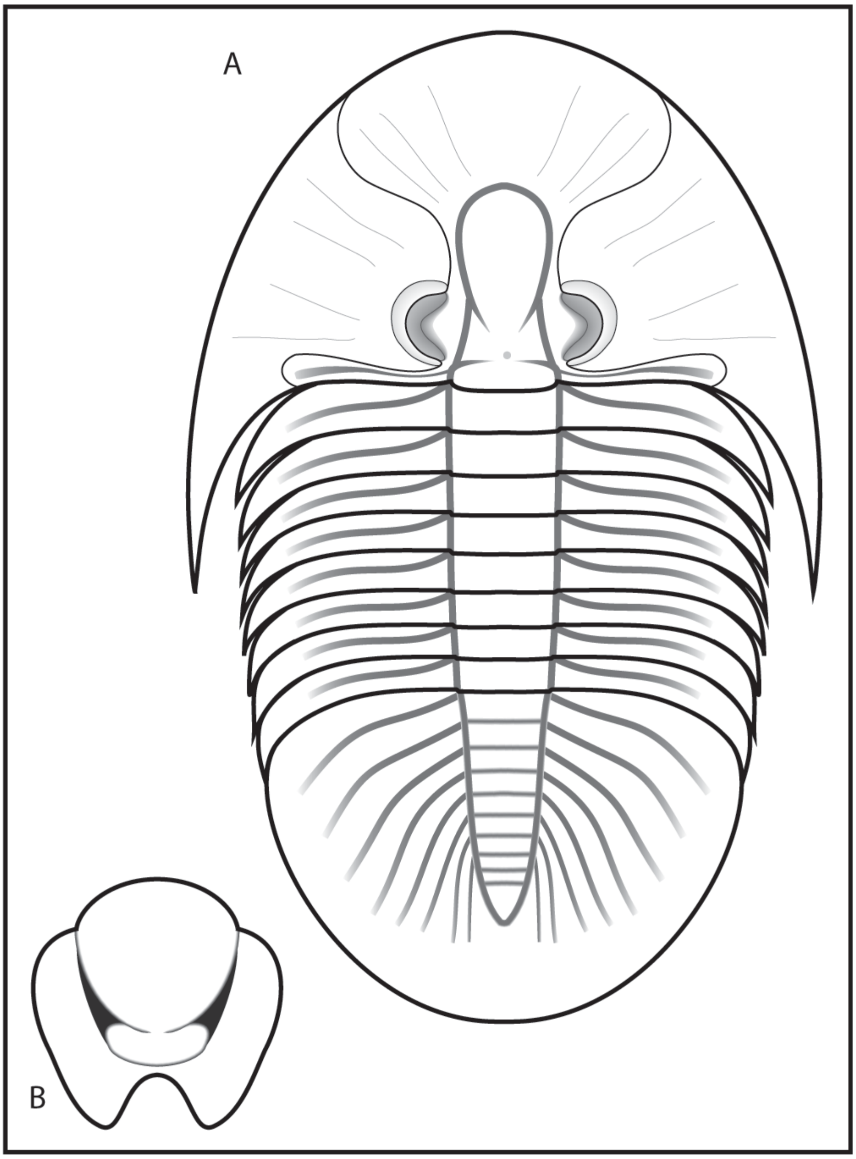

FIGURE 7. Reconstruction of *Birmanites birmanicus* (Reed). A) Dorsal skeleton; B) Hypostome.

Discussion. The type series is imperfect, but sufficient to support the diagnosis given by Lu (1975). Well-preserved material of *Birmanites* in full relief is rare. Where it is known (e.g. *Birmanites politus* Lu, 1975, pl. 8, fig. 8; also see Zhou & Dean 1986, pl. 59. fig. 14; Chugaeva 1958, pl. 4, fig. 1; Ghobadi Pour *et al.,* 2011) the glabella shows more details than we have available on the type series of *B. birmanicus,* notably a posterior median glabellar tubercle, and two closely spaced, narrow and short glabellar furrows on the flanks of the frontal glabellar lobe. The least distorted of Reed's specimens (Fig. 6.6) shows the posterior glabellar furrow opposite the palpebral lobe. The radially disposed ridges on cheeks and preglabellar area are variably developed and may be exaggerated by flattening. They are, however, also shown on *Birmanites yangtzeensis* Lu (1975, pl. 8, figs 9,11) and '*Ogygites*' *al-*

matyensis Chugaeva (1958, pl. 4, fig.1). Placing Reed's (1915, pl. 7, fig.2; Fig. 6.5 herein). *Megalaspis* aff. *hyorhina* (Schmidt ,1906) into *Birmanites birmanicus* leaves no doubt about the high divergence of the facial sutures in front of the eye (we were not able to cast the whole of this cranidium from its counterpart), and this specimen also shows faint radial ridges supporting our determination. Zhou & Zhen (2008) show *Birmanites* ranging through much of the Chinese Ordovician. While *B. yangtzeensis* is similar in cephalic characters to *B. birmanicus*, its pygidium shows interpleural furrows and has a relatively wide border.

***Birmanites yunnanensis* (Reed, 1917)**

Figs 8.1–6

1917	*Ogygites yunnanensis* Reed, p. 42-45, pl. 6, figs 12–14; pl. 7, figs 1–8.
1951	*Basiliella yunnanensis* (Reed); Kobayashi, p. 33, pl. 4, figs 7,8.
1965	*Basilicus* (*Basiliella*) *yunnanensis* (Reed); Lu *et al*. p. 481–2, pl. 94, fig. 17, *non* figs 15,16.
2008	*Birmanites yunnanensis* (Reed); Zhou & Zhen, p. 236.
2014	*Birmanites yunnanensis* (Reed); Zhang *et al*., figs 5.41F,G.

Material. Lectotype (selected here): articulated thorax, pygidium and incomplete cephalon, Fig. 8.5 (Reed, 1917, pl. 6, fig. 12 and pl. 7, fig. 4; refigured Lu et al. 1965, pl. 94, fig. 17), GSI 11887 and 11893. Assigned specimens: free cheeks, Figs 8.4, 8.6 (Reed, 1917, pl. 7, fig. 5; pl. 6, figs 13/14; pl. 7, fig. 3, respectively), GSI 11894, 11889, 11892, respectively; pygidia, Figs 8.2, 8.3 (Reed, 1917, pl. 7, figs 8, 6 respectively) GSI 11897, 11895, respectively. Reed (1917) also figured fragmentary thoracic segments and other pieces of cephalic exoskeleton that were not cast: thoracic segments pl. 7, figs 1, 2, GSI 11890, 11891, respectively; pygidium pl. 7, fig. 7, GSI 11896. All specimens from the Shihtien Formation (Darriwilian) at Pupiao, Baoshan Prefecture, western Yunnan.

Description. The original material of Reed (1917) is only slightly distorted and presumably also flattened to some degree. The most complete articulated specimen is not preserved at the front, but the exoskeleton must have been about 1.6-1.7 times longer than wide, and the sag. length of the thorax is close to that of the pygidium. Since there is no associated cranidium its shape has to be inferred from the outline of the facial sutures, which are strongly divergent in front of the eyes. We can estimate that the sag. length of the cranidium in front of the eyes was greater than its length behind them, but less so than on *B. birmanicus*, such that the anterior part of the cranidium was presumably wide and flattened. A well preserved cranidium from the Shihtien Formation figured by Zhang *et al.* (2014, fig. 5.41F) confirms these estimations and shows a prominent posteromedian glabellar tubercle. Smaller free cheeks show a lateral border and it was likely that these extended on to the cranidium at small size (e.g. Fig. 8.4) but probably effaced on larger individuals (e.g. Fig 8.1). Since the thoracic axis is well-defined it is probable that this continued into the axial furrows also defining the glabella. The strongly curved eyes are elevated on eye socles, length (exsag.) about 30% that of cranidium to judge from the unseparated free cheeks on Fig. 8.6. Genal lateral border well-developed, particularly on smaller free cheeks, which are extended into stout genal spines, but a certain amount of crushing may have exaggerated the concavity of the border, which is hardly developed on the specimen in Fig. 8.4. This specimen also shows the typically wide genal doublure of *Birmanites*, with sparse terrace ridges. Paradoublural line on the right-hand side of the specimen in Fig. 8.6 suggests that the doublure was less extensive at smaller size. The thorax shows somewhat zetoidal axial furrows and axial rings of uniform transverse width. Thoracic pleurae widen backwards. Left-hand side of thorax Fig. 8.5 has flaked off to show the dorsal surface of reflexed doublure which extends under distal parts of pleural furrows; distal tips of pleurae apparently blunt, or at most shortly spinose. Pygidium in range 1.3 to 1.6 times wider than long, with very weak, slightly flatter border most noticeable behind axis; the latter extending to 70-75% pygidial length. Narrow axis, axial furrows enclosing an angle of about 20 degrees, and three times or more as long as wide, with maximum width immediately behind thorax, tapering uniformly posteriorly. 5 or 6 clearly-defined axial rings slightly decreasing in width (sag.) posteriorly, and clear ring furrows a little wider and more diffuse medially. Articulating facet extends halfway or more across pleural field. Six pairs gently curved pleural furrows progressively more posteriorly directed and then shorter, the gently convex ribs between them also narrowing (exsag.). Ribs fade at the border. Doublure clearly seen on composite Fig. 8.2, very broad, curving back almost to axis, and with series of widely spaced terrace ridges typical for genus. The lectotype shows evidence of fine raised lines running subparallel to the pygidial margin, but otherwise there is no evidence of sculpture.

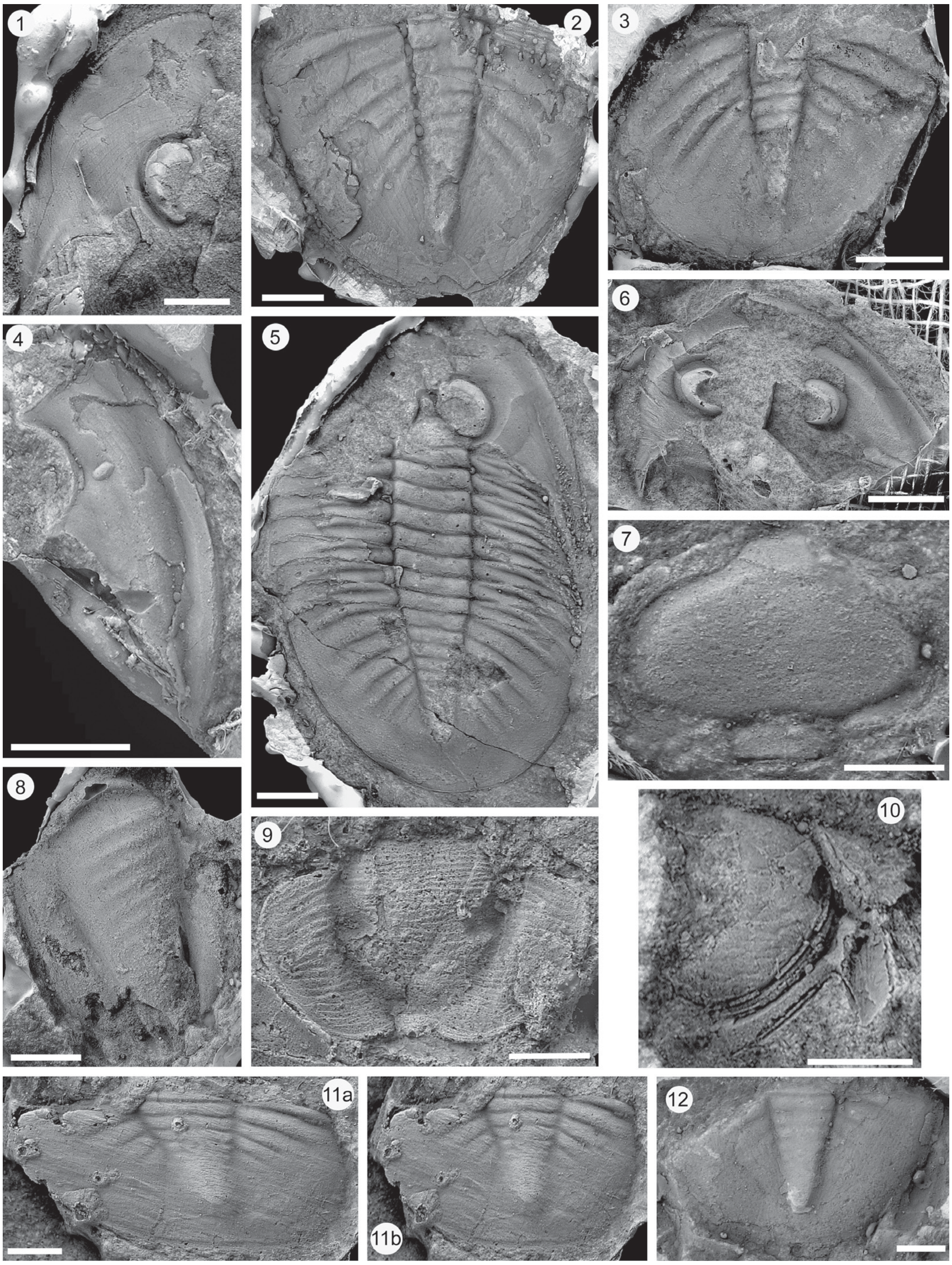

FIGURE 8. (1–6) *Birmanites yunnanensis* (Reed) from the Shihtien Formation (Darriwilian), Pupiao, Baoshan Prefecture, western Yunnan, China. 1. Librigena (original of Reed 1917, pl. 7, fig. 3), GSI 11892. 2. Pygidium (original of Reed 1917, pl. 7, fig. 6), GSI 11895. 3. Pygidium (original of Reed 1917, pl. 7, fig. 8), GSI 11897. 4. Librigena (original of Reed 1917, pl. 7, fig. 5), GSI 11894. 5. Articulated specimen (original of Reed 1917, pl. 6, fig. 12), GSI 11887. 6. Cephalon (original of Reed 1917, pl. 6, fig. 14), GSI 11889. (7, 10) Remopleuriidae gen. et sp. indet. (Reed) from the Shihtien Formation (Darriwilian), Pupiao, Baoshan Prefecture, western Yunnan, China. 7. Cranidium, (original of Reed 1917, pl. 6, fig. 9), GSI 11884. 10. Librigena (original of Reed 1917, pl. 6, fig. 10), GSI 11885. (8) *Dolerobasilicus*? sp. (Reed), Pygidium (original of Reed 1915, pl. 7, fig. 3), GSI 11535, Lower Naungkangyi Beds, Nawa, northern Shan State, Myanmar. (9) *Nileus* sp., Hypostome (original of Reed 1917, pl. 8, fig. 5), GSI 11904, Shihtien Formation (Darriwilian), Pupiao, Baoshan Prefecture, western Yunnan, China. (11, 12) *Niobe* sp. (Reed). 11a, b. Pygidium (original of Reed 1915, pl. 5, fig. 14), GSI 11516, Hwe Mawng Beds (uppermost Katian), Nati, northern part of Shan State, Myanmar, original and retrodeformation. 12. Pygidium (original of Reed 1917, pl. 6, fig. 11), GSI 11886, Shihtien Formation (Darriwilian), Shidian, Baoshan Prefecture, western Yunnan, China. Scale bars = 5 mm for 1–6, 8, 9; = 2 mm for 7, 10–12)

Discussion. The individual selected here as the lectotype has a part and counterpart with two different GSI designations (11887 and 11893, respectively). GSI 11887 is a more complete specimen containing almost all of the thorax and all of the pygidium. GSI 11893 is only a small portion of thorax and the free cheek. Identical deformation signatures leave little doubt that these are the same individual though Reed (1917) did not recognize them as such. Although quite well preserved, the type material does not include a cranidium. However, Zhang *et al*. (2014, fig. 5.41F) illustrated a cranidium from western Yunnan associated with a pygidium (fig. 7.41G) identical to those of *B. yunnanensis* from the type collection that confirms an assignment to *Birmanites*. Kobayashi (1951) had assigned *B. yunnanensis* to *Basiliella*, a genus clarified by Zhou & Fortey (1986) and not close to *Birmanites,* and more typical of lower palaeolatitude limestone facies of North China. The smaller free cheeks of *B. yunnanensis* have lateral borders which are better defined than on most illustrated species of *Birmanites*, but this is likely to be an earlier ontogenetic feature, since small birmantines can have well-defined genal borders (e.g. *Birmanites hupeiensis* Zhou, Yin & Tripp, 1984, fig. 3e; *Opsimasaphus jaanussoni* Kielan, 1960, pl. 7, fig. 2). Reed (1917, pl. 7, fig. 3) illustrated a larger free cheek with the doublure extending to the eye lobe and carrying widely spaced terrace ridges, typically birmanitine. The cast from this specimen (Fig. 8.4) has a feeble lateral border and shows much of the course and extent of the facial suture, which is compatible with the cranidium figured by Zhang *et al.* (2014). Similarly, wide doublure with terrace ridges is seen on the pygidium illustrated in Reed (1917, pl. 7, fig. 6) but the impression of the ridges is less clear on the cast from the counterpart of that specimen used here (Fig. 8.2). *Birmanites yunnanensis* differs from the type species and many others in having relatively straight (not distally backwardly curved) pygidial pleural furrows, while the axis is about 70% total pygidial length. Generally similar pygidia are displayed by the Sandbian-Katian *B. qilangensis* Zhang, 1981, from Xinjiang (Tarim) (see Zhou *et al.,* 2014, fig. 29 A-C) and by *B. hupeiensis* Yi 1957, from the Darriwilian Shihtzupu Formation of Guizhou Province. The latter had been erroneously identified with *B. yunnanensis* by Sun (1931) and Kobayashi (1951) and placed in the genus *Basiliella* by the latter (see Zhou *et al.,* 1984, p. 17). The free cheeks illustrated by Zhou *et al.* (1984, fig. 3e) are very similar to Reed's illustrated here in Fig. 8.6, with regard to development of the border. However, if the cranidium assigned to *B. yunnanensis* in Zhang *et al.* (2014) is correct, then the preglabellar area of *B. hupeiensis* is relatively much longer (sag.).

Mioptychopyge Zhou *et al.*, 1998

Type species. *Ptychopyge trinodosa* Zhang 1981, Dawangou Formation, Xinjiang, original designation.

Mioptychopyge thebawi (Reed, 1915)

Fig. 9

1915	*Ptychopyge thebawi* sp. nov. Reed, p. 32–34, pl. 6, figs 5–8.
1915	*Ptychopyge (Basilicus) titanica* sp. nov. Reed, p. 35, pl. 6, figs 11–12, pl. 7, fig. 1.
1998	*Mioptychopyge thebawi* (Reed, 1915); Zhou, Dean, Yuan & Zhou, p. 706.

Material. Lectotype (selected here): cranidium from Hkawnhkok, Fig. 9.4 (Reed, 1915, pl. 6, fig. 7), GSI 11527. Hkawnhkok. Additional type material: cranidium from Nawng Yun, Fig. 9.1 (Reed, 1915, pl. 6, fig. 5), GSI 11525; cranidium from Mong Ha, Fig. 9.8 (Reed, 1915, pl. 6, fig. 6), GSI 11526; pygidium from Mong Ha, Fig. 9.5 (Reed, 1915, pl. 6, fig. 8), GSI 11528. Additional material: hypostome from Lilu, Fig. 9.3 (Reed, 1915, pl. 6, fig. 9), GSI 11529; 3 pygidia from Hwe Mawng, Figs 9.3,6,7 (Reed, 1915, pl. 7, fig. 1; pl. 6, figs 12, 11, 39 respectively), GSI 11533, 11532, 11531 respectively. All specimens from Hwe Mawng Beds (uppermost Katian) at Hkawnhkok, Hwe Mawng, Lilu, Mong Ha, Nawng Yun.

Description. Most of the material illustrated by Reed (1915) is a little distorted, and plausible retrodeformations are also used herein. Cranidia are not transversely convex and would originally have been of similar width (tr.) along the posterior margin as they are long sagitally. Glabella occupies about 70% cranidial length (sag.), with maximum width across the frontal lobe close to 60% sag. length. Frontal lobe pyriform and extended (sag.), with anterior part in front of maximum width forming a semicircle in outline, and posterior part tapering regularly to level of glabellar tubercle; furrows defining it rather uniformly shallow. Although the furrows appear continuous the posterior parts are slightly deeper and here comprise the S1 glabellar furrow. The probable course of the posterior part of the axial furrow is shown on the right-hand side of the holotype as a shallow furrow running more or less exsagitally. Hence the glabella is constricted at the level of the eyes to about two-thirds its maximum width at the front, and then widens posteriorly to a similar transverse width at the posterior margin. Prominent glabellar tubercle at one-fifth glabella length, opposite posterior part of the palpebral lobes, which are highly curved with weak rims, and of length (exsag.) one quarter that of glabella. Although they are close to the glabella there are small (exsag.) inflated areas adjacent to the palpebral lobes, which lie outside the axis. Postocular fixed cheek is very narrow (exsag.) proximally, wider laterally, and much of it is taken up by wide posterior border furrow that widens laterally. Preocular fixed cheeks merge with wider, flat preglabellar area. Facial sutures are recurved forwards behind the eyes, anterior branches diverging at about 40 degrees to sag. Line before curving adaxially in a smooth curve to meet at midline in a distinct point, so there presumably supramarginal. Free cheek not assigned. A hypostome (Fig. 9.2) is imperfectly preserved but shows a long (sag.) middle body that is compatible with the long anterior glabellar lobe of this species. The relatively short fork has a U-shaped profile, and the lateral border is not flared, as in several other asaphid genera.

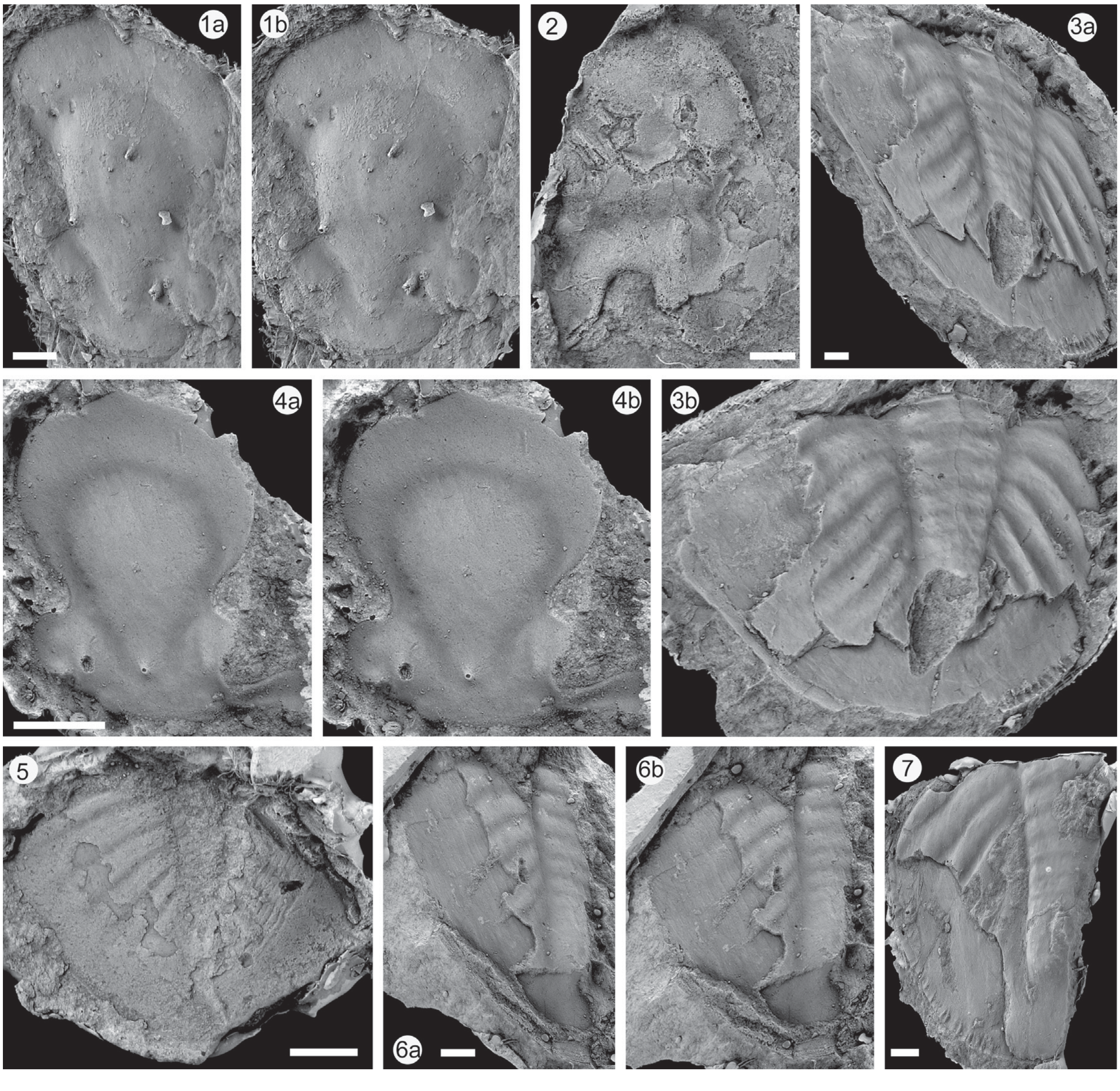

FIGURE 9. *Mioptychopyge thebawi* (Reed) from the Hwe Mawng Beds (uppermost Katian) and Li-Lu Formation (Katian), northern Shan State, Myanmar. 1a, b. Cranidium (original of Reed 1915, pl. 6, fig. 5), GSI 11525, Nawng Yun, original and retrodeformation. 2. Hypostome (original of Reed 1915, pl. 6, fig. 9), GSI 11529, Lilu. 3a, b. Pygidium (original of Reed 1915, pl. 7, fig. 1), GSI 11533, Hwe Mawng, original and reetrodeformation. 4a, b. Cranidium (original of Reed 1915, pl. 6, fig. 7), GSI 11527, Hkawnhkok, original and retrodeformation. 5. Pygidium (original of Reed 1915, pl. 6, fig. 8), GSI 11528, Mong Ha. 6a, b. Pygidium (original of Reed 1915, pl. 6, fig. 12), GSI 11532, Hwe Mawng, original and retrodeformation. 7. Pygidium (original of Reed 1915, pl. 6, fig. 11), GSI 11531, Hwe Mawng. Scale bar = 5 mm for 1, 3–7; = 2 mm for 2.

A pygidium (Fig. 9.5) assigned by Reed (1915) is incomplete but apparently not distorted, and of a size that would be appropriate for the lectotype cranidium; it would have been two-thirds as long as wide when complete. Five pleural ribs, of which four are well defined, the fifth fainter, while the pleural furrows fade out over half-way across the pleural field. The pygidial axis is not well-preserved, but must have had narrow proportions (approximately three times as long as wide), and presumably a minimum of five axial rings to accord with the pleural ribs. The doublure, closely reflexed against the dorsal surface and carrying terrace ridges, extended quite far beneath the distal parts of the pleural furrows, but did not extend to the axis. Reed (1915) also described some very large pygidia under the name *Ptychopyge* (*Basilicus*) *titanica*, all of which have undergone distortion. When retrodeformed (Figs 9.3b,6b) these are plausible as large specimens of *M. thebawi*, showing five ribs which fade towards the pygidial margin and a similarly narrow pygidial axis. A paradoublural line on the largest pygidium indicates that the doublure closely approached, but did not reach, the axis. A sixth axial ring is observed and long terminal piece apparently without dorsal furrows. On the small pygidium there are faint indications of interpleural furrows, but their apparent absence in the large pygidia is probably accounted for by changes during later ontogeny.

Discussion. Zhou *et al.* (1998) assigned *Ptychopyge thebawi* Reed, 1915, to their new genus *Mioptychopyge*, when redescribing the type species, *M. trinodosus* Zhang, 1981, from Yunnan Province. These authors assigned an additional three Chinese species to *Mioptychopyge*, all of them named later than *M. thebawi*. *Mioptychopyge trinodosus* has a distinct anterior border furrow on the cranidium, and a wider pygidial axis than *M. thebawi*, but shorter and weaker pygidial pleural ribs. The comparison with the typically Baltic genus *Ptychopyge* and its allies is based on the ogival form of the anterior branches of the facial sutures, which must have been supramarginal. However, it is also possible to compare Asian species with the Subfamily Birmanitinae, as discussed above, for example in the elongate pyriform glabella with prominent posterior tubercle. Many Baltic ptychopygines have a pair of distinctive inflated nodes at the anterior proximal edges of the fixigenae which are not seen in the Chinese species (see discussion in Turvey, 2007, p. 361), and this may prove to be a synapomorphy of the former group. *Birmanites brevicus* Xiang & Zhou, 1987 from Tarim, revised by Zhou *et al.* (1998), is very similar to *M. thebawi* with the exception of a rounded anterior junction of the facial sutures at the cephalic margin. Its pygidium does not have the curved ribs typical of *Birmanites*. It may prove to be closer to *Mioptychopyge*. *Mioptychopyge suni* (Endo, 1935) revised by Turvey (2007) is also generally similar to *M. thebawi*, but has much larger palpebral lobes and feebly developed pygidial pleural ribs. Closer to *M. thebawi* is a species referred by Turvey (2007) to *Opsimasaphus*, *O. pseudodawanicus* (Lu, 1975), from the Siliangssu Formation, southern China. Although the palpebral lobes on the well-preserved cranidium illustrated by Turvey (2007, pl. 3, fig. 14) are larger than on Reed's *M. thebawi*, this cranidium is also much smaller, and it is generally true in asaphids that the proportional length of the eye diminishes during later ontogeny (e.g. *Asaphellus* see Fortey & Owens, 1991). It is possible that this difference is just a matter of ontogeny, and in other features the cranidia are similar (compare retrodeformed Fig. 9.4b herein with Turvey, 2007, pl. 3, fig. 13) apart from a more posteriorly curved anterior branch of the facial suture in *O. pseudodawanicus*, and a fragmentary larger cranidium (Turvey, 2007, pl. 4, fig. 1) does appear to show a wider preglabellar area. The pygidium of *O. pseudodawanicus* is like that of *M. thebawi* in having strongly developed pleural ribs, but up to eight are developed on the former. Turvey (2007) gave a lengthy discussion on the generic placement of *pseudodawanicus*, and the possible differentiating features of *Opsimasaphus*, and clearly recognised that *Birmanites*, *Opsimasaphus* and *Mioptychopyge* comprise a closely related, and indeed intergrading plexus. The incomplete information we have on *M. thebawi* does not help arbitration on these genera, and it is here retained in *Mioptychopyge* as Zhou *et al.* (1998) suggested.

Subfamily Niobinae Jaanusson, 1959

Niobe Angelin, 1851

Type species. *Asaphus frontalis* Dalman, 1827, subsequently designated Vogdes, 1890.

***Niobe*? sp.**

Figs 8.11,12

1915 *Asaphus* cf. *ornatus* Pompeckj; Reed, p. 29–30, pl. 5, fig. 14.

Material. Pygidium from the Hwe Mawng Beds (uppermost Katian) at Nati, Fig. 8.11 (Reed, 1915 pl. 5, fig. 14), GSI 11516. Reed (1915, p. 30) also mentions an asaphid thorax from a much larger individual, unfigured, but we did not locate this specimen.

Discussion. A cast from the counterpart of the specimen figured by Reed (1915) shows some lateral extensive deformation, and a simple retrodeformation of this specimen is shown in Fig. 8.11b, suggesting that the pygidium was originally slightly less than twice as wide as long. It is not otherwise badly preserved. Four progressively shorter and relatively well-defined pleural ribs fade under halfway across the pleural fields, and interpleural furrows are not developed. Four (faint fifth) axial rings on the axis, of which only the first two pass across the mid part of the axis, posterior 40% of the axis slightly convex and unfurrowed. The termination of the ribs usually marks the inner edge of the doublure in asaphids, which would indicate a straight line converging on the posterior part of the axis, around which it would be deeply embayed. The pygidial border is hardly developed. The structure of the pygidium is more like that of a niobinid than any other asaphid group. In the type species of the genus the pygidium has a well-developed border and lobe-like pleural rib terminations, but this is not true of all species that have been attributed to *Niobe*. No post-Tremadoc species are currently recognised in China (Zhou & Zhen, 2008). However, two specimens of thorax + pygidium figured by Lu *et al.* (1965, pl. 94, figs 15, 16) under the name *Basiliella yunnanensis* (Reed) are much more like the *Niobe* considered here in their short pygidial pleural furrows, and unlike the type material of *yunnanensis* considered above. Outside China, the closest match is probably with the pygidium of the holotype of *Niobe occulta* Fortey, 1975 from the late Floian of Spitsbergen (Fortey, 1975, pl. 6, fig.1) with slightly longer pleural furrows and more axial rings, but without cephalic sclerites it is not possible to make further comparison. In view of the stratigraphical difference from other niobines it is identified with question accordingly. A small pygidium from the Shihtien Formation at Pupiao, Yunnan, described by Reed (1917, pl. 6, fig. 11) as *Asaphus* aff. *expansus* is more similar to that of *Niobe* sp. than other asaphid pygidia (see Fig. 8.12) although with one less pleural furrow. It is recorded here as *Niobe* sp.

Subfamily Basilicinae Jaanusson in Moore, 1959

***Dolerobasilicus* Kobayashi, 1934**

Type species *Dolerobasilicus yokusensis* Kobayashi 1934

***Dolerobasilicus*? sp.**

Fig. 8.8

1915 *Megalaspis* sp.; Reed 1915, p. 36, pl. 7, fig. 3.

Material. Incomplete pygidium from the Lower Naungkangyi Beds (probable Darriwilian) at Nawa, Fig. 8.8 (Reed, 1915, pl. 7, fig. 3), GSI 11535.

Discussion. Although this species is known only from one incomplete pygidium, enough is preserved to show that it has an unusually deeply curved, elongate profile, relatively narrow axis and prominent ribs. Reed (1915) compared this specimen with the pygidium of *Megalaspis* (now *Megistaspis*) a diverse genus that is confined to the Baltic palaeoplate in the Ordovician. A more plausible comparison is with *Dolerobasilicus,* described from Korea. Revision of *Dolerobasilicus yokusensis* Kobayashi 1934 by Lee & Choi (1988) includes several pygidia (e.g. Lee & Choi, 1988, pl. 1, fig. 9) with similar elongate form and about ten ribs. While the evidence is incomplete, it is sufficient to suggest the presence of this genus in Myanmar.

Family Nileidae Angelin, 1854

Nileus Dalman, 1827

Type species. *Asaphus* (*Nileus*) *armadillo* Dalman, 1827, Lower Ordovician, Sweden.

Nileus sp.

Fig. 8.9

1917 *Nileus armadillo* Dalman; Reed, p. 49–50, pl. 8, fig. 5.

Material. Hypostome from Shihtien Formation (Darriwilian) at Pupiao, Fig. 8.9 (Reed, 1917, pl. 8, fig. 5), GSI 11904.

Discussion. Reed (1917) correctly associated this hypostome with Nileidae, but his identification with *Nileus armadillo* on the basis of this sclerite alone was hardly justifiable in view of the difference in age. His identification of a second *Nileus* species (Reed 1917, pl. 8, fig. 6) on the basis of a free cheek cannot be supported as the eye is too small and the anterior course of the suture wrong for this genus. Several genera of Nileidae have been added since Reed's time, and their hypostomes are conservative, with broad lateral borders converging in a shallow embayment with a median tooth. The Burmese species has strong, relatively sparse, nearly transverse terrace ridges compared with many species. The closest match we can find is with the hypostome of *Nileus symphysuroides* Lu, 1957, as illustrated by Zhou *et al.* (2016, pl. 52, fig. 13) from the Pagoda Limestone (Katian) and widespread in China. Without the rest of the exoskeleton the identification is cautious.

Family Remopleurididae Hawle & Corda, 1847

Remopleuridid gen. et sp. indet.

Figs 8.7,10

1917 *Remopleurides* aff. *latus* Olin; Reed, p. 41, pl. 6, figs 9,10.

Material. Cranidium, Fig. 8.7 (Reed, 1917, pl. 6, fig. 9), GSI 11884; free cheek, Fig. 8.10 (Reed, pl. 6, fig. 10), GSI 11885; both specimens from the Shihtien Formation (Darriwilian) at Pupiao, western Yunnan.

Discussion. Reed (1917, p. 41) compared this species with one from the Chasmops limestone of Norway. Reed's illustration of the cranidium shows the usual thin, arched glabellar furrows of remopleuridids; the cast figured here taken from the mould does not show such furrows, which are therefore probably visible only on the internal mould. We assume following Reed that the free cheek belongs with the cranidium, although the eye seems to be deeper than usual, and its inner profile does not closely match that of the palpebral lobes on the cranidium. However, the latter could be transversely extended through modest distortion. The number of remopleuridid genera in China has been increased as the former *Remopleurides sensu lato* has been subdivided. Zhou *et al.* (2016) recognised *Hexacopyge* and *Disloboaspis* alongside *Remopleurides* itself, in the Pagoda Formation, for example. Details of the hypostome are crucial to discriminate these clades, and since that feature is lacking in Reed's collection it must remain in open nomenclature.

Family Raphiophoridae Angelin, 1854

Lonchodomas Angelin, 1854

Type species. *Ampyx rostratus* Sars, 1835, see Whittington (1959).

Lonchodomas shanensis (Reed, 1915)

Fig. 10.3,6

1915 *Ampyx rostratus* var. *shanensis*; Reed 1915, p. 24–25, pl. 5, figs 2,3.

Material. Lectotype (selected herein): disarticulated, incomplete dorsal exoskeleton from Mong Ha, Fig. 10.6 (Reed, 1915, pl. 5, fig. 2), GSI 11504. Other material: cranidium from Hwe-hok, Fig. 10.3 (Reed, 1915, pl. 5, fig. 2), GSI 11505. Both specimens from the Hwe Mawng Beds (uppermost Katian).

Description. The disassociated exoskeleton indicates that the sag. length of the cephalon (to the base of the anterior spine) is similar in length to the rest of the thorax + pygidium. Glabella with the shape of a narrow and elongate rhomb. There is no indication of lateral glabellar muscle impressions, nor of the lateral lobes developed by some species attributed to *Lonchodomas*. The maximum glabellar width is probably slightly less than half its length. The transverse convexity of the glabella is very low posteriorly, hardly elevated above the cheeks, and the occipital ring is hardly defined. An indistinct median crest runs along the anterior half of the glabella and is extended into a stout frontal spine of unknown length, which from its base probably had a prismatic cross section. Posterior border furrow shallows towards glabella; so far as it can be observed posterior border arches slightly forwards. Free cheeks not observed. Four thoracic segments clearly shown, and traces of the fifth, posterior segment to the left of the pygidium; thorax is probably subparallel sided, or with a gentle posterior taper. Transverse width of pleurae similar to that of axis, which is weakly convex; long (sag.) articulating half rings present. Pleural tips truncate; weak pleural furrows just posterior to median line and gently concave. Pygidium distinctive, just over twice as wide as long, with a moderately well-defined axis initially just over one-third anterior pygidial width, and this similar to its length, making a neat isosceles triangle as it tapers to border, axial furrows enclosing an angle of 50 degrees. Apart from half-ring, ring furrows not expressed. Distinct anterior pleural furrow elegantly concave laterally, and behind it one shallow but straight pleural furrow making a near right angle to the axial furrow and extending to border. Border itself is steeply downturned and of similar height along its length.

Discussion. The most distinctive specific characters of this raphiophorid are on the pygidium, with its axis making an almost equilateral triangle, and only two well marked pleural furrows, the second quite different from the first. It differs from *L. rostratus* (Sars, 1835) (e.g. Whittington, 1959) in these characters, and in having a narrower and less carinate glabella. Hence Reed's "var." is employed as a specific name. Although it cannot be proved that there was no sixth thoracic segment, the evidence we have supports the presence of five segments, typical of *Lonchodomas*. Reed (1915, p. 25) noted only four segments, presumably not recognising the fragmentary fifth segment on the left-hand side. A number of *Lonchodomas* species have been described from China, but none has the peculiar pygidial structure of *L. shanensis*. Curiously, a similar pygidium is present on *Maiopopsis whittardi* (Yi, 1957) (e.g. Lu, 1975, pl. 42, fig. 4), but *Maiopopsis* has a completely different cephalic structure to that of *Lonchodomas*, and the pygidial similarities are surely a matter of convergence. Cephalic features of *Lonchodomas* remain relatively conservative from early in the history of the genus (Nielsen, 1995).

Ampyx aff. *macullumi* from the Upper Naungkangyi Beds figured by Reed (1915, pl. 5, figs 4-6) and refigured here (Figs 10.1,2) shows a carinate glabella and apparently prismatic frontal spine, and may be referable to *Lonchodomas*. However, the pygidum referred by Reed to this species is unlike that of *L. shanenis* and probably does not belong with the cranidium. It is here retained under open nomenclature as *Lonchodomas*? sp.

Family Dionididae Gürich, 1907

Dionide Barrande, 1847

Type species. By original designation of Barrande (1847, p. 391) *Dione formosa* Barrande, 1846, Katian of Bohemia (Czech Republic).

Dionide hybrida Reed, 1915
Fig. 10.4

1915 *Dionide hybrida* sp. nov.; Reed, p. 26–27, pl. 5, fig. 7.
1940 *Digrypus hybridus* (Reed); Kobayashi, p. 207, text-fig 2.

Material. Holotype: Cranidium part and counterpart from Hwe Mawng Beds (Upper Katian) of Hwe-hok, Myanmar, Fig. 10.4, GSI 11509.

Description. The species is founded upon a single, reasonably well-preserved cranidium. The illustration herein is of a cast from the counterpart of the holotype figured by Reed (1915, pl. 5, fig. 7), the convex (tr.) cranidium slightly more than twice as wide as long, with the preglabellar field occupying 15% of the cranidial length (sag.). Glabella in front of the occipital ring with almost circular dimensions, but with gently constricted sides, transversely evenly convex. The prominent glabella tubercle is at glabellar mid-length (occipital ring included). The basal lateral glabellar lobes are more or less incorporated into the glabella, but their extent is revealed as slight bulges in the axial furrows, which are not apparent on the original drawing in Reed (1915). The posterior ends approach the lateral edges of the occipital ring. A small part of the otherwise effaced furrows defining their inner edges is deepened into a pair of small subcircular glabellar furrows. The depressed and narrow (sag.) occipital ring about two-thirds glabellar width, defined by an occipital furrow which is shallower and wider medially. Axial furrows narrow, shallowest around posterolateral glabellar lobes. Thin and deep posterior border furrow is probably incomplete as it extends to genal angle in *Dionide* (this seems to be shown on the right hand side of the 1915 illustration). Posterior border hardly convex, slightly wider (exsag.) than occipital ring. Fixed cheeks convex adjacent to glabella and downsloping to fairly narrow concave border that maintains nearly even width around the anterior perimeter, such that at the midline the preglabellar area is very short (sag.), about one-sixth of length of glabella behind (sag.). Left hand side suggests a prolonged genal extension posteriorly. The dorsal surface of cheeks is pitted, with the larger pits following the inner edge of the anterior border. Reed's (1915) illustration emphasises this feature, but it is not so clearly marked on the cast, where more noticeable pits are concentrated in front of the glabella. Backwardly directed principal genal vein is not well developed, but a narrow ridge can be seen on the left-hand side of the cranidium Fig 10.4, which follows a course similar to that of other species of *Dionide*.

Discussion. Among numerous *Dionide* species only a few have a preglabellar area well short of half the length of the glabella (sag.). One of them is the type species, *D. formosa* (Barrande, 1846) the lectotype of which is illustrated in Horný & Bastl (1970, pl. 13, fig. 3, see also Šnajdr, 1990, p. 193). The main differences between the cranidium of *D. hybrida* and that of *D. formosa* are the wider fixed cheeks of the former and its more rectangular glabella, as well as more prominent surface sculpture of the latter. *Dionide miaopoensis* Lu, 1975) (also Peng *et al.*, 1991) from the Upper Ordovician Maiopo Formation of Hubei Province also has a narrow preglabellar area but appears to resemble *D. formosa* rather than *D. hybrida* in the same differential features. A much older species with A cranidium like that of *D. hybrida* is *D. levigena* Fortey & Owens, 1987, from the "late Arenig-early Llanvirn" (Dapingian to early Darriwilian) of South Wales (also Kennedy & Stammers, 2018, fig. 235) which has an almost circular glabella, and at least one example with cheeks as narrow (tr.). A clear difference is the separate convexity of the cheek lobe on *D. levigena*, which merges gently with the border in *D. hybrida.* A Chinese species of similar age to *D. hybrida*, *D. regalis* Lu & Zhou, 1981 (see Tripp *et al.*, 1989, fig. 12) has a cranidium of which can hardly be distinguished from that of the Myanmar species; possibly, the gena is more convex and distinctly caecate. Kobayashi (1940) made *Dionide hybrida* the type species of a new genus, *Digrypus*, but we consider that there are not sufficient distinctions from *Dionide formosa* and other *Dionide* species to justify this taxon.

Family Pliomeridae Raymond, 1913

Pliomerina Chugaeva, 1956

Type species. *Pliomera martellii*, Reed, 1917, original designation.

Discussion. The type species of *Pliomerina* is part of Reed's collection, but this is known only from the cranidium, redescribed here. Silicified and complete material from Australia described by Webby (1971, p. 614) is doubtless congeneric with the Myanmar type species, and provides a fuller diagnosis than is possible from the type material alone. Webby (1971) pointed out that *Pliomerina* is widely distributed across Australasia and adjacent territories, extending from Kazakhstan in the north to New South Wales, Australia, in the south, with additional occurrences on the South China plate, Sibumasu and Korea, i.e. palaeotropical Gondwana on current palaeocontinental reconstructions. Webby preferred the term "*Pliomerina* fauna" to cover this Ordovician biogeographic region to "*Encrinurella* fauna" coined by Whittington & Hughes (1972), though they embrace a similar geographic compass. Zhou & Zhen (2008) record the genus through much of the post-Tremadocian Ordovician of China, including northeastern Chinese and Tibetan occurrences.

Pliomerina martellii **(Reed, 1917)**

Fig. 10.7

1917 *Pliomera martellii*; Reed, 1917, p. 55–56, pl. 8, figs 15,16.

Material. Holotype: cranidium from Shihtien Formation (Darriwilian) of Pupiao, Fig. 10.7 (Reed, 1917, pl. 8, figs 15,16) GSI 11915, Pupiao, western Yunnan, southwestern China.

Description. Cranidium twice as wide as long. Glabella with low transverse convexity, maximum inflation across frontal lobe, greatest width at L3 is 1.3 times that across occipital ring, and slightly less than sagittal length. Anterior outline of glabella at cranidial margin is gently and evenly arcuate about the mid-line. Deep glabellar furrows extend less than one-third across glabella: S1 slightly curving backwards, S2 hardly so, and S3 distinctly inward-backwardly directed making an angle of about 30 degrees to the transverse line. Since this specimen is not a true dorsal surface the furrows may well have been longer and narrower on the exterior surface. The latter is undoubtedly also true of the deep and wide axial furrows that expand in width towards the anterolateral glabellar corners. Of glabellar lobes L3 is most inflated and widens abaxially; its greatest width (exsag.) is twice that of narrow L1 and 1.5 that of L2. Occipital furrow curves forwards in a broad arc medially, such that the occipital ring is widest in its central two-thirds. The anterior cranidial border is developed as a narrow ridge anterolaterally, but narrows and merges with the frontal lobe of the glabella adaxially. Silicified material figured by Webby (1971) shows that it remains just distinct from the glabella on the exterior surface but this is not expressed on the internal mould. Fixed cheeks three-quarters as wide (tr.) as maximum width of glabella, narrow (exsag.) posterior limb bisected by deep, wide border furrow (as preserved). Medium sized palpebral lobe extends back as far as L2, the area inside it narrow (tr.) and inflated. There is some evidence of a reticulum in this area.

Discussion. Reed (1917, p. 56) referred to the type species being "represented by only two head-shields showing the cast and impression" and Webby (1971, p. 614) in turn referred to "two incomplete cranidia". The type material consists of a single individual cranidium in part and counterpart, as Reed probably implied. Although it is preserved in full relief most of its features suggest that we are seeing the internal surface of this cranidium, and this should be taken into account in comparing with other species assigned to *Pliomerina*. Nonetheless, despite the lack of the associated pygidium from the type locality, with its characteristic well-defined elongate terminal piece, the species assigned to *Pliomerina* by Chugaeva (1958), Webby (1971) and listed in Zhou & Zhen (2008) form a tight group. A squat glabella with some lateral inflation of L3 is typical. However, *P. tashanensis* Lee, 2013, from Jiangxe Province, China, has an elongate glabella with somewhat effaced furrows, no lateral prominence of L3, and the pygidial terminal piece is not inflated; it is not typical of the genus. Cranidia of *P. australis*, Webby (from Australia) of similar size to the holotype of *P. martellii* (e.g. Webby, 1971, pl. 115, fig. 1) have a more deeply arcuate or parabolic outline of the frontal glabellar lobe, although smaller individuals like the holotype (Webby, 1971, pl. 114, figs 2-7) are more similar to *P. martellii* in this regard. However, the fixed cheeks are narrower (tr.) and the inflation of L3 more marked. Of three Katian species from Kazakhstan described by Chugaeva (1958) *P. dulanensis* is probably most similar to *P. martellii*, although its glabellar furrows are longer and more curved forwards. Possibly the most similar species to *P. martellii* is *P. serrata* described by Zhou & Zhou (2006) from Katian strata in Inner Mongolia; it may have longer glabellar furrows. An 'outlier' of the genus in Argentina (Edgecombe *et al*., 1999) provides good evidence that a segment of the Precordillera was part of Gondwana by the later Ordovician. It should be noted that Reed (1917) reported this species from several localities, but this is not reflected in the collections.

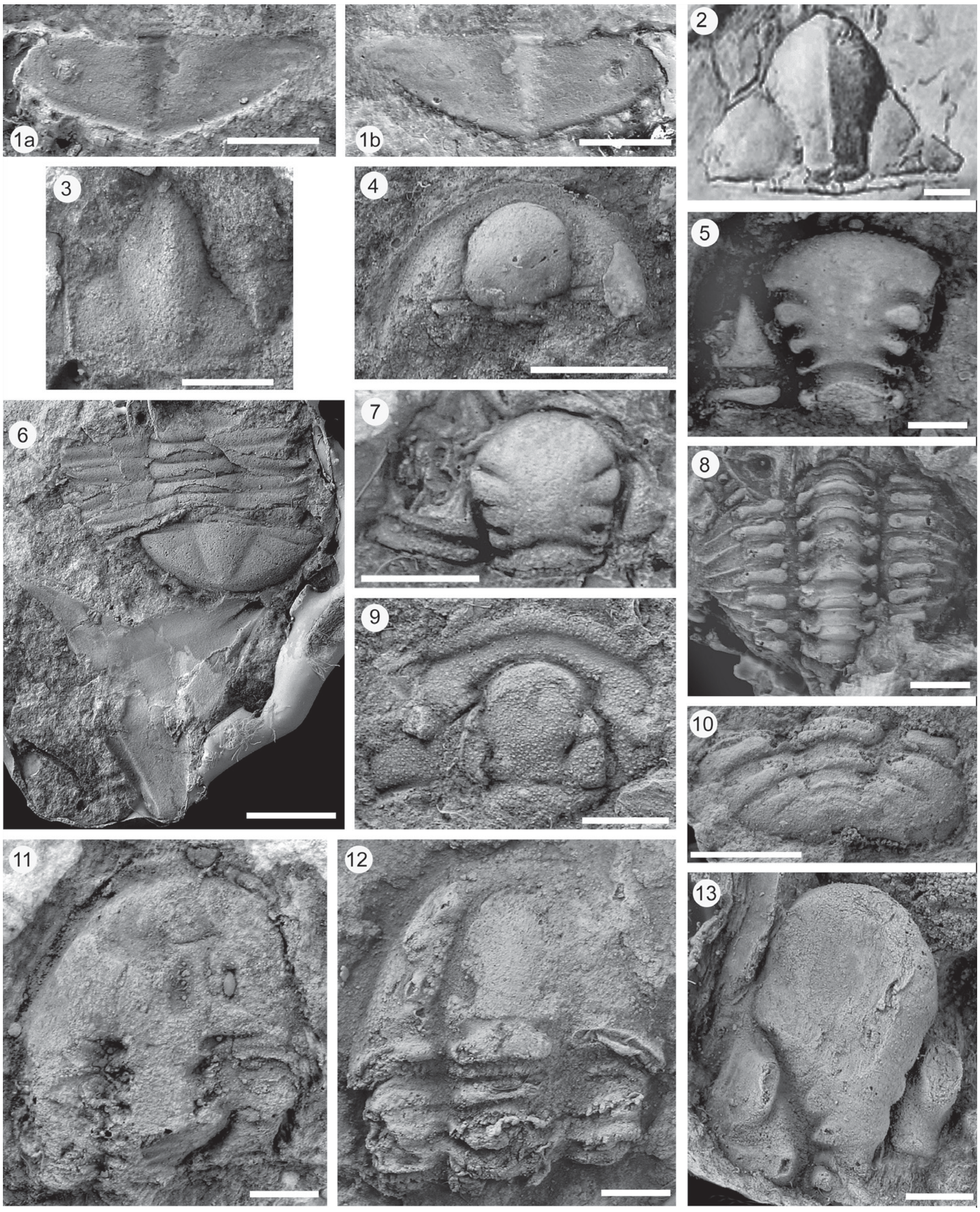

FIGURE 10. (1, 2) *Lonchodamas*? sp. (Reed) from the Li-Lu Formation (Katian), Lilu, northern Shan State, Myanmar. 1a, b. Pygidium (original of Reed 1915, pl. 5, fig. 6), GSI 11508, original and retrodeformation. 2. Cranidium (refigured from Reed 1915, pl. 5, fig. 5), GSI 11507. (3, 6) *Lonchodamas shanensis* (Reed) from the Hwe Mawng Beds (uppermost Katian), northern Shan State, Myanmar. 3. Pygidium (original of Reed 1915, pl. 5, fig. 3), GSI 11505, Hwe-hok. 6. Cranidium (original of Reed 1915, pl. 5, fig. 2), GSI 11504, Mong Ha. (4) *Dionide hybrida* (Reed), Cephalon (original of Reed 1915, pl. 5, fig. 7), GSI 11509, Hwe Mawng Beds (uppermost Katian), Hwe-hok, northern Shan State, Myanmar. (5, 8) *Ovalocephalus*? sp. indet. (Reed) from the Li-Lu Formation (Katian), Mân-ngai, northern part of Shan State, Myanmar. 5. Cranidium (original of Reed 1915, pl. 8, fig. 17), GSI 11563. 8. Thorax (original of Reed 1915, pl. 8, fig. 21), GSI 11567. (7) *Pliomerina martellii* (Reed), Cranidium (original of Reed 1917, pl. 8, fig. 15), GSI 11915, Shihtien Formation (Darriwilian), Pupiao, Baoshan Prefecture, western Yunnan, China. (9) *Prionocheilus liluensis* (Reed), Cranidium (original of Reed 1915, pl. 8 figs 6 and 7), GSI 11554, Li-Lu Formation (Katian), Lilu, northern Shan State, Myanmar. (10, 13) *Ovalocephalus* sp. (Reed) from the Li-Lu Formation (Katian), Lilu, northern Shan State, Myanmar. 10. Pygidium (original of Reed 1915, pl. 8, fig. 9), GSI 11556. 13. Cephalon; not previously figured; no GSI catalogue number. (11, 12) *"Calymene" oldhami* (Reed) from Lower Naungkangyi Beds (probable Darriwilian), Mâ Shio, northern Shan State, Myanmar. 11. Cephalon and thorax (original of Reed 1915, pl. 8, fig. 11), GSI 11558. 12. Cephalon and partial thorax (original of Reed 1915, pl. 8, fig. 10), GSI 11557. Scale bars = 2 mm for 1–3, 6, 8–13; = 5 mm for 4, 5; = 1 mm for 7.

Encrinurella Reed, 1915

Type species. By monotypy, *Pliomera insangensis* Reed, 1906, Naungkangyi Beds, northern part of the Shan State.

Encrinurella insangensis (Reed, 1906)

Fig. 11

	1906	*Pliomera insangensis* sp. nov.; Reed, p. 74–76, pl. 5, figs 19–25.
	1915	*Pliomera (Encrinurella) insangensis* Reed; Reed, p. 50–51, pl. 8, figs 15, 16, 18–20; *non* figs 17, 21.
cf.	1998	*Encrinurella* sp.; Fortey & Cocks, fig. 3N.

Material. Lectotype (selected herein): cranidium from Hweyawt, Fig. 11.9 (Reed, 1906, pl. 5, figs 21,22), GSI 8335. Additional type material: cephalon with hypostome and pygidium from Hweyawt, Fig. 11.10 (Reed, 1906, pl. 5, figs 19, 23), GSI 8334; pygidium from Insang, Fig. 11.7 (Reed, 1906, pl. 5, fig. 20), GSI 8336; cranidium from Kunlein, Fig. 11.4 (Reed, 1906, pl. 5, fig. 24), GSI 8338; partial thorax from Ledet, Fig. 11.8 (Reed, 1906, pl. 5, fig. 25), GSI 8339. Additional material: cephalic shield from Hweyawt, Fig. 11.1 (Reed, 1915, pl. 8, fig. 16), GSI 11562; cephalic shield from Man Ngai, Fig. 11.2 (Reed, 1915, pl. 8, fig. 15), GSI 11561; cephalic shield from Makmongshai, Fig. 11.3 (Reed, 1915, pl. 8, fig. 18), GSI 11564; 2 pygidia from Man Ngai, Figs 11.5,6 (Reed, 1915, pl. 8, figs 19,20 respectively), GSI 11565, 11566 respectively. All material from the Li-Lu Foramtion (Upper Naungkangyi Beds; Katian) at Hweyawt, Insang, Kunlein, Ledet, Makmongshai, or Man Ngai.

Description. The lectotype is distorted, and even with attempted retrodeformation it is not entirely symmetrical. Undistorted cephalic shield from Reed's later collection twice as wide as long, with maximum glabellar width across frontal lobe slightly exceeding that across genal area. A good cephalic shield (Fig. 11.3) is somewhat flattened and is relatively slightly wider across the frontal lobe, but there is probably still some transverse extension on this specimen, which also has more divergent axial furrows. The general resemblance between most of the specimens in different preservational states is still sufficient to suggest that one species is involved (but see comments below). Forward expansion of glabella is ten to fifteen degrees as measured to sagittal line on good material. Glabellar furrows short and deep, and with characteristic form: S1 gently concave forwards, S2 transverse or nearly so, while S3 is distinctly convex forwards, apostrophe shaped. Glabellar lobes accordingly vary in shape, with L1 very narrow (exsag.) especially laterally near axial furrow, L2 subrectangular, nearly twice as wide (exsag.) as L1, L3 longer again, more rounded, and appearing slightly inflated. Occipital ring extends laterally as far as, or slightly beyond L1, where it is noticeably narrower than in its median two-thirds. Occipital furrow curves forwards over this part, laterally deepening in line with glabellar furrows. Dorsal furrows are deep, including the axial furrows, but this is because the figured specimens are mostly internal moulds: the cast from the dorsal surface (Fig. 11.3) shows narrower furrows in general. This specimen also shows the posterior cranidial border most faithfully: gently convex, and hardly widening laterally, defined by deep but narrow border furrow. The border furrow is much exaggerated on the internal mould and the border appears narrower and more convex. Prominent semicircular palpebral lobes are located opposite L3 at about one quarter of the transverse width of the adjacent glabella, the eye lobe as a whole standing proud and about one quarter length (exsag.) of glabella in front of occipital ring. Cheeks inside palpebral lobes gently convex, as also behind the eye lobe. Postocular cheek triangular, more or less bisected by the posterior border furrow. Course of facial suture best seen on Fig. 11.10, showing anterior branch running near to the axial furrow and curving anteriorly closely around the frontal lobe of the glabella, outlining a narrow cranidial border there; posterior branch diverges behind the eye and runs to genal angle. One of Reed's (1906) specimens (Fig. 11.10) has the glabella broken to reveal the outline of the hypostome beneath. It has a rounded-triangular outline tapering posteriorly and surrounded by a narrow and convex border. There is a suggestion of marginal denticles, especially close to the midline.

The narrow free cheek extends forwards in a spine-like way to form the narrow border in front of the glabella. In dorsal view the wide, outward-sloping lateral cranidial border is dominant, outlined by a deep and wide marginal furrow. The convex eye is elevated on an eye socle which is defined at the base by a furrow running parallel to the border furrow, though half the width. Between this furrow and the border furrow an elevated and convex ridge is parallel to the lateral border. An incomplete thorax of eight segments is plausibly associated (Fig. 11.8) (compare with that of *Encrinurella tetrasulcata* Ju *in* Tripp *et al.*, 1989, fig. 14k) showing convex axial rings of equal width having a small anterior forward turn like that on the occipital ring. Very prominent half rings are almost as long (sag.) as the axial rings themselves. Posterior pleural bands of similar width (exsag.) and convexity to axial rings, their outer halves steeply downturned to blunt tips. Anterior pleural bands very narrow (exsag.) depressed below level of posterior bands from which they are separated by transverse furrow extending as far as the pleural articulation. Pygidium has pleural ribs of similar form to thorax anteriorly and is twice as wide long, or somewhat longer; none is perfectly preserved. Four (? five) axial rings of decreasing width and length on gently tapering axis; terminal piece not clearly seen, but presumably very small and triangular. Five pairs of bluntly tipped pleural ribs turned downwards marginally, and progressively posteriorly directed, the rear pair behind the axis and running more or less exsagitally.

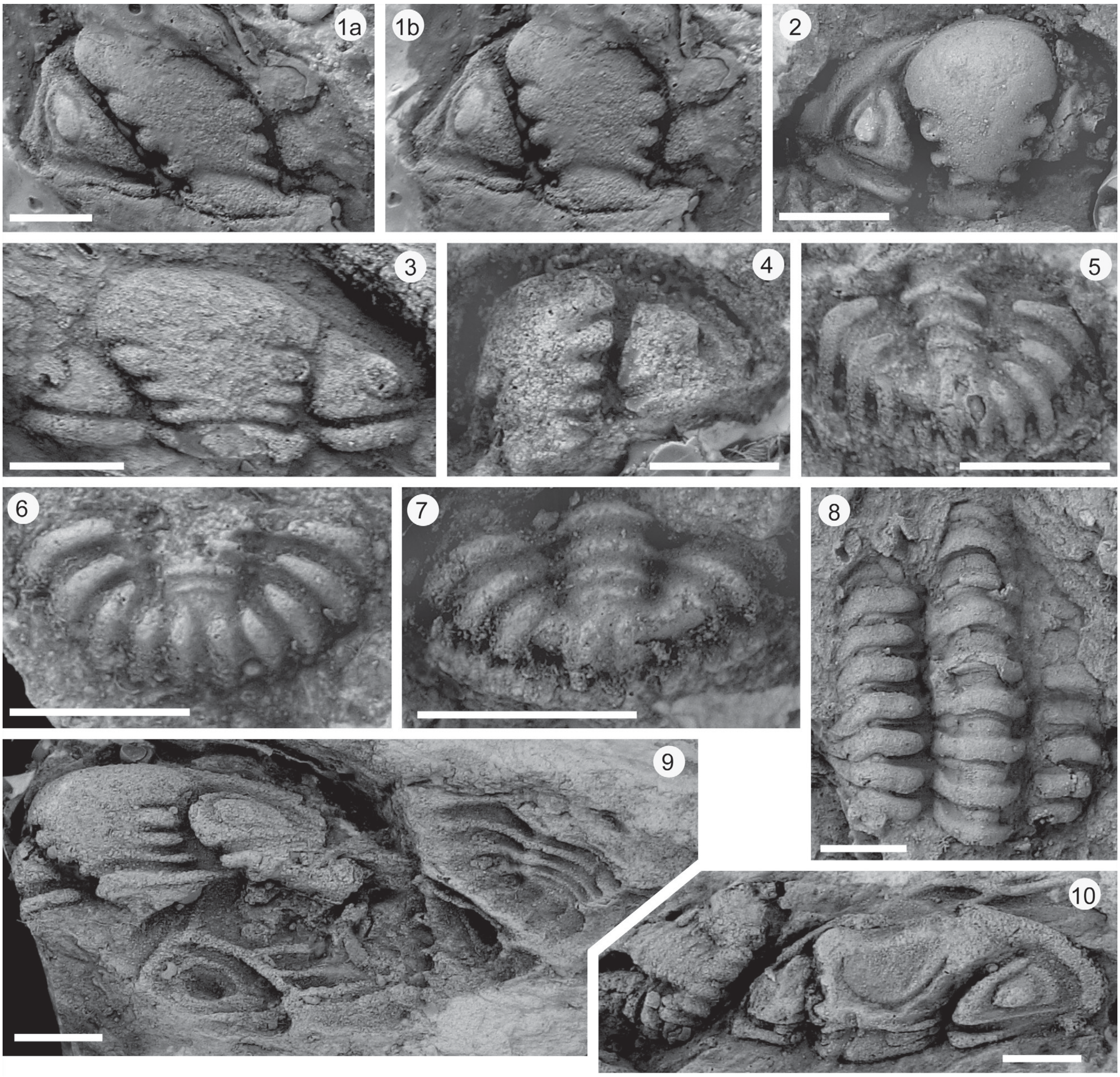

FIGURE 11. *Encrinurella insangensis* (Reed) from the Li-Lu and Kunlein Formations (Katian), northern Shan State, Myanmar. 1a, b. Cranidium (original of Reed 1915, pl. 8, fig. 16), GSI 11562, Hweyawt, original and retrodeforamtion. 2. Cranidium (original of Reed 1915, pl. 8, fig. 15), GSI 11561, Mân-ngai. 3. Cranidium (original of Reed 1915, pl. 8, fig. 18), GSI 11564, Makmongshai. 4. Cranidium (original of Reed 1906, pl. 5, fig. 24), GSI 8338, Kun-lein. 5. Pygidium (original of Reed 1915, pl. 8, fig. 19), GSI 11565, Mân-ngai. 6. Pygidium (original of Reed 1915, pl. 8, fig. 20), GSI 11566, Mân-ngai. 7. Pygidium (original of Reed 1906, pl. 5, fig. 20), GSI 8336, Insang. 8. Thorax (original of Reed 1906, pl. 5, fig. 25), GSI 8339, Ledet. 9. Cranidium and pygidium (lectotype, original of Reed 1906, pl. 5, figs 21&22), GSI 8335, Hweyawt. 10. Cranidium and pygidium (original of Reed 1906, pl. 5, figs 19 and 23), GSI 8334, Hweyawt. Scale bars = 2 mm.

Discussion. We are obliged to select a lectotype from the Reed (1906) collection even though less distorted examples are present in the 1915 collection. The cranidium figured here as Fig. 11.9, original of Reed 1906, pl. 5, fig. 22, is selected, numbered GSI 8335, which has the advantage of an associated pygidium and partial cephalon showing the eye lobe. The type material from Reed (1906) belongs to the single species *Encrinurella insangensis*, and most of the material he figured in 1915 can be confidently assigned to the same species. However, the internal mould of a cranidium figured here in Fig. 10.5, original of Reed (1915, pl. 8, fig. 17) differs from that of *E. insangensis* in several respects, notably in having wider glabellar furrows, smaller L1, and indications of coarse tubercles upon it, which may have been prominent on the dorsal surface. It also shows development of inflated circular lobes at the ends of the occipital ring. These seem to be real features rather than artifacts of preservation. The latter feature may relate to a partial thorax (Fig. 10.8) that also displays inflated lobes at the ends of the thoracic axial rings, with a convex lobe also on the proximal parts of the pleural bands. This thorax clearly belongs to a different species from the thorax of *E. insangensis* in Fig. 11.8. These specimens are both excluded from *E. insangensis*. The cranidium is very tentatively recorded here as *Ovalocephalus*? sp. indet.; the thorax may also belong to the same species.

Ovalocephalus Koroleva, 1959

Type species. *Ovalocephalus ovatus* Koroleva 1959, original designation, Upper Ordovician, Kazakhstan.

Ovalocephalus sp.

Figs 10.10,13

pars	1915	*Calymene* (*Pharostoma*) *liluensis* Reed; Reed, pl. 8, fig. 9.
?	1915	*Pliomera* (*Encrinurella*) *insangensis* Reed; Reed, p. 8, fig. 21.

Material. Pygidium from the Li-Lu Formation (Upper Naungkangyi Beds; Katian) at Nam Tu above Lilu, northern Shan State, Myanmar, Fig. 10.10 (Reed, 1915, pl. 8, fig. 9), GSI 11556; Cranidium from unknown northern Shan State horizon and locality, Fig. 10.13, unregistered and not previously figured by Reed.

Description. A single example of a pygidium is twice as wide as long, and with low transverse convexity. Anterior transverse width of the axis is approximately equal (tr.) to the anterior part of the pleural lobe. Axis tapers, but is effaced posteriorly, and rings low and band-like, three clearly defined by gently forwardly arched ring furrows that continue on to pleural fields. Fourth ring furrow faint, and narrow; no defined terminal piece. Pleural ribs: two well-defined gently downsloping to margin, the first probably slightly exceeding it, with deep pleural furrows between; third rib incompletely defined by shallow furrow that does not extend to margin. Narrow and convex articulating ridge visible on left hand side.

The external mould of a small cranidium was also discovered and cast while investigating the Reed collections, but we can find no indication that Reed examined it. The preservation is similar to that of other specimens from the "Upper Naungkangyi Beds" from northern Shan State and it is figured herein for the record Fig. 10.13).

Discussion. This pygidium described above is typical of those belonging to the genus *Ovalocephalus* Koroleva, and Reed (1915) was mistaken in associating it with the calymenoid cranidium on his pl. 8, figs 6,7. Zhou *et al.* (2010) reviewed the synonymy, taxonomy and included species of *Ovalocephalus* Koroleva. The single pygidium figured here is important as the first record from the Reed collections of a genus that is widely recorded in the Ordovician of eastern Asia and certain Kazakh terranes, and can be regarded as an indicator of subtropical Gondwana and peri-Gondwanan terranes until the late Katian, when it migrated to western Gondwana in response to what has been claimed as a short-lived episode of global warming (Fortey & Cocks, 2005). The pygidium is not determinable to species, but is unlike the stratigraphically earlier species reviewed in Zhou *et al.* (2010), which have noticeably posteriorly-turned pleural ribs. As an internal mould, the pleural furrows appear wider than in many species figured from better material. *O. kanlingensis* Zhang, 1981 (Darriwilian-Sandbian, material figured in Zhou *et al.,* 2010) has similarly arranged pleural ribs, although the Reed material is inadequate for confident determination.

As noted above, two specimens attributed to *Encrinurella insangensis* by Reed (1915) are excluded from that species. The cranidium (Fig. 10.5) shows inflated posterolateral glabellar lobes, which appear to be part of the occipital ring. They resemble the circular basal glabellar lobes of *Ovalocephalus*, but these are pre-occipital (Zhou *et* *al.*, 2010). It is conceivable that the lobes on the Burmese specimen have migrated backwards to a (pseudo) occipital position. There are indications on the internal mould of the glabella of large tubercles, which were presumably expressed on the dorsal surface. A partial thorax (Reed, 1915, pl. 8 fig. 21; Fig. 10.8) displays lateral inflated areas on the axial rings, which suggests it could belong with the cranidium. While excluded from *Encrinurella*, these specimens are possibly closer to *Ovalocephalus*, although if coarse tubercles are present it is unlike other species of that genus.

The unlocalised cranidium (Fig. 10.13) is more consistent with similarly preserved specimens of *Ovalocephalus*, including the type species *O. tetrasulcatus* Kielan, 1960. However, Zhou *et al.* (2010) illustrated a number of other late Ordovician *Ovalocephalus* species with elongate (sag.) glabellas with short glabellar furrows and our internal mould here is inadequate for precise identification. It is conceivable that it is the cranidium appropriate to Reed *Ovalocephalus* sp. pygidium but we cannot prove this without further collections.

Family Calymenidae Burmeister, 1843

Subfamily Pharostomatinae Hupé, 1953

Prionocheilus Rouault, 1847

Type species. *Prionocheilus verneuli* Rouault, 1847, by monotypy.

Discussion. We accept the priority of the generic name *Prionocheilus* over *Pharostoma* (see Dean 1971). Reed (1915, p. 46) erected a species based on a cranidium, *Calymene* (*Pharostoma*) *liluensis*, which might be regarded as a *Prionocheilus* species. Zhou *et al.* (1977) erected the genus *Xuanenia*, type species *X. pustulosus* Zhou, 1977, from central South China, based on an imperfectly preserved cranidium. The same genus and species were subsequently described by Tripp *et al.* (1989) for material from the Upper Ordovican Tangtou Formation, Jiangsu Province. The similarity of some of this material to '*Pharostoma*' *liluensis* was noted already by Fortey & Cocks (1998), and is confirmed by the present study. Tripp *et al.* (1989) remarked that "*Xuanenia* is extremely close to *Prionocheilus* Roualt, 1847 (sic)[and] differs only in the effaced lateral glabellar lobes and furrows and smaller pygidium with fewer segments." There is little difference with regard to glabellar lobes and furrows between the cranidium figured by Tripp *et al.* (1989, fig. 17k) and the type specimen of '*Pharostoma*' *liluensis*, which in turn is not significantly different from cranidia of *Prionocheilus* spp.; we prefer to use that generic name pending further clarification of *Xuanenia*. It is possible that *P. liluensis* has priority over subsequently named species in this group, but a comparative study of adjacent species is needed to clarify this.

Prionocheilus liluensis (Reed, 1915)
Fig. 10.9

1915 *Calymene (Pharostoma) liluensis*; Reed, p. 4647, pl. 8, figs 6, 7, *non* pl. 8, fig. 9.

Material. Holotype. Cranidium GSI 11554. Reed (1915, p. 47) did not associate the pygidium he figured with confidence, and it is therefore not to be regarded as one of the type series. Since this pygidium is that of an *Ovalocephalus* sp. (above) the cranidium is the only type specimen available for holotype. Reed illustrated part and counterpart of this specimen. Upper Naugkangyi Beds (Katian). Lilu right bank of Nam Tu, path to Manping. northern Shan State.

Description. The external mould of the holotype is illustrated herein, and is reasonably well-preserved, although the tip of the fixed cheek is not present. Glabella occupies three-quarters of cranidial length (excluding occipital ring), and is as wide as long; occipital ring 25% total glabellar length. Glabella best preserved on right side showing convex flanks narrowing forwards to broadly arcuate front. Deep S1 with outer end at three-eighths cranidial length, curving inwards but fading well before occipital furrow, distally not quite becoming exsag. S2 follows in line with inner part of S1, and shallower, its anterior termination just behind a prominent anterior pit at the end of the axial furrow. L1 is twice as wide and twice as long as L2, and both somewhat inflated. Occipital ring well defined, narrows laterally, and carries a prominent circular median tubercle. Preglabellar field as wide (sag.) as border in front near midline, and widens towards corner of glabella. Palpebral lobe situated about 40% of the distance across the adjacent glabella, and of similar length (exsag.) to preglabellar field (sag.). Eye ridges strong and convex, directed back at about 60 degrees to sag. line. Anterior border furrow of even, moderate depth along its length. Border hardly convex and gently bowed forwards. Posterior border furrow as deep as axial furrows, and posterior section of fixed cheek presumably broadly triangular. Facial sutures diverge at a low angle in a convex curve in front of the palpebral lobes and at a high angle behind. Much of the dorsal surface is covered by fine tubercles, which appear coarser and sparser immediately in front of the preglabellar furrow and on the postocular fixed cheeks. A cranidium described by Kolobova (*in* Sokolov & Yolkin,1978, pl. 27, fig. 7) under the name *Pharostoma inermis* from the Upper Ordovician of Tien Shan is very like that of *Prionocheilus liluensis*, although it apparently has coarser tubercles on the dorsal surface.

Subfamily Reedocalymeninae, Hupé, 1955

Reedocalymene Kobayashi, 1951

Type species. *Calymene unicornis* Reed, 1917, Pupaio Formation, Yunnan, original designation.

Discussion. Reed's (1917) species is the nominated type species of *Reedocalymene*, although Lu (1975) described much better preserved material of the same genus. In a cladistic analysis of the Subfamily Reedocalymeninae Turvey (2002) showed that *Reedocalymene* and *Calymenesun* Kobayashi, 1951 are closely related. Lu (1975, p. 448) had noted this previously, and provided some distinguishing characters, supplemented further by Peng *et al*. (2000). However, some of these are contradictory. Lu (1975, p. 447) stated of *Calymenesun* that "the pygidium is quite different from all others of the Calymenids [sic] in having a very narrow border." On p. 448 he states (of similarity between the two genera) that they share "a broad border on the pygidium". He stated also that an important feature is the shape of the glabella which is claimed as "semioval" in *Reedocalymene*, as it is on *R. expansa* Yi (see Lu, 1975, pl. 46, fig. 4). However, the lectotype of *R. unicornis* shows a wider part of the glabella at the level of the basal lobes, which is actually more like that of the type species of *Calymenesun, C. tingi* Sun (Lu, 1975, pl. 46, figs 9,12). As discussed by Peng *et al.* (2000) the distinction between the two genera, both erected by Kobayashi (1951), is not clearcut, and they may eventually be synonymized. We follow these authors in recognizing the two genera *pro tem*.

Reedocalymene unicornis (Reed, 1917)

Figs 12.1–6,8,10

1917	*Calymene unicornis* sp. nov.; Reed p. 52–54, pl. 8, figs 10–13.
1951	*Reedocalymene unicornis* (Reed, 1917); Kobayashi, p. 45, pl. 4, figs 12–14.
1975	*Reedocalymene unicornis* (Reed, 1917); Lu, p. 447.
2002	*Reedocalymene unicornis* (Reed, 1917); Turvey, p. 55.
2005	*Reedocalymene unicornis* (Reed, 1917) Turvey, p. 550.

Material. Lectotype (selected by Turvey, 2005): damaged cephalon, Figs 12.1-3 (Reed, 1917, pl. 8, fig. 10), GSI 11913. Additional type material: cephalic fragments, Figs 12.5/8 and 12.10/6 (Reed, 1917, pl. 8, figs 12,11 respectively), GSI 11912; pygidium, Fig. 12.4 (Reed, 1917, pl. 8, fig. 13), GSI 11911? All material from the Shihtien Formation (Darriwilian) at Pupiao, western Yunnan.

Discussion. Reed (1917) described the limited material of this species in some detail, and new cast material does not greatly enhance our knowledge. The lectotype is more distorted than Brock's original drawing suggests, and the upward curvature of the anterior pro/jection shown by Reed (1917, pl. 8, fig. 10a, GSI 11913) may have been exaggerated by this. However, the comparatively laterally expanded L1 on the glabella is probably a real feature, which is not so clear on the original drawing. This differs from other species assigned to the genus by Lu (1975) that have a uniformly deeply parabolic glabellar outline. In this respect *R. unicornis* more closely resembles species that have been assigned to *Calymenesun* and *Vietnamia* (see Turvey, 2002). However, it is possible that deformation may have contributed to this distinction. A very incomplete cranidium shows the outline of the posterior fixed cheek. A backwardly displaced free cheek with a narrow border is best displayed on Reed's pl. 8, fig. 11; we have not been able to cast this specimen, nor the only example of a pygidium (Reed, 1917, pl. 8, fig. 13) reproduced here. The imperfect thorax and pygidium from Pupiao figured by Reed (1917, pl. 8, fig. 14) is refigured here (Fig. 12.7). It is likely to belong to a reedocalymenine, and possibly to *Reedocalymene* rather than *Neseuretinus*. However, the pygidial pleural ribs appear to be more pronounced than is the case with the pygidium assigned with more certainty to *R. unicornis* by Reed (1917, pl. 8, fig.13), and its assignment must remain uncertain.

Neseuretinus Dean, 1967

Type species. *Neseuretinus turcicus* Dean, 1967, Sandbian, Bedinan Formation, Turkey, original designation.

Neseuretinus birmanicus (Reed, 1906)

Figs 12.9,11–15

Synonymy. See Turvey, 2005, p. 560; also Ghobadi Pour & Popov 2009

Material. Lectotype (selected Turvey, 2002, p. 560): cranidium from probable Lower Naungkangyi Beds (probable Darriwilian) at Kunkaw, Fig. 12.9 (Reed, 1906, pl. 5, fig. 27), GSI 8341. Additional material: pygidium from Lower Naungkangyi Beds (probable Darriwilian) at Loikok, Figs 12.14,15 (Reed, 1915, pl. 8, fig. 5), GSI 11553; 2 cranidia from Upper Naungkangyi Beds (Katian) at Lilu (Reed, pl. 8, figs 1,4), GSI 11549, 11552 respectively; cranidium from Hwe Mawng Beds at Pa-hki (Reed,1915, pl. 8, figs 2), GSI 11550; pygidia from the Lower and Upper Naungkangyi Beds (Katian) at Lilu and Loi Kok (Reed, pl. 8, figs 3,5), GSI 11551, 11553 respectively. Material from new collections: crandidium, pygidium with partial thoracic segment, and pygidium from Pupiao Formation (Katian) at Pupiao, Figs 12.11–13, CMC 91532–91534 respectively.

Discussion. Turvey (2005) gave a full description of this species, and it is not necessary to reillustrate all Reed's material in this work. The lectotype is refigured here for the record. Well-preserved articulated specimens from Iran attributed to *N. birmanicus* have been described by Ghobadi Pour & Popov (2009), who included several other species in their synonymy. As presently conceived, *N. birmanicus* has a long stratigraphic range. The type material is likely to come from the Lower Naungkangyi Beds and is probably Darriwilian in age, as is material from Loikok. This is the same age as the good specimens from Iran figured by Ghobadi Pour and Popov (2009). However, the other specimens in Reed (1915) refigured by Turvey (2005) are from the Upper Naungkangyi Beds and Katian in age. It does seem unlikely that a single species would have such an extensive stratigraphical range. Ghobadi Pour (written communication 2021) has pointed out that the Katian pygidia have eight pleural ribs, whereas Darriwilian examples from Iran and Myanmar have six ribs. If this is consistent, it does suggest that there are two taxa involved under the name *birmanicus*. *Neseuretinus* specimens from Uzbekistan figured by Kolobova (*in* Sokolov & Yolkin, 1978, pl. 27, figs. 1-5) under the name *Calymenesun tingi* were reassigned to *Neseuretinus turcicus* by Hammann & Leone (1997) and have six pygidial pleural ribs. There is also another poorly nown species from Afghanistan described by Wolfart (1970) (*Neseuretinus malestanus*) that may be an available name for the Katian species, with relevant Reed specimens illustrated by Turvey (2005). For present purposes we separate the Katian species from the Darriwilian type material as *Neseuretinus* aff. *birmanicus* pending a comparative treatment of all these taxa.

Also figured are some additional specimens of *Neseuretinus* aff. *brimanicus* collected from the Pupiao Formation at the Pupiao section in Baoshan Prefecture, W. Yunnan by NCH in 1999. These specimens provide a connection between Katian strata in northern Shan State and western Yunnan. However, a cranidium from the Shihtien Formation attributed to *N. birmanicus* in Zhang *et al.* (2014, fig. 5.41E) differs from the type of *N. birmanicus* in having a more rectangular glabella and more anteriorly positioned palpebral lobes. The palaeogeographical distribution of *Neseuretinus* was also discussed by Turvey (2002) who noted its wide distribution across Ordovician Gondwana and inferred its probable phylogeny. GSI 11550 figured by Turvey (2005, pl. 2, fig. 9) is reported as being from the Hwe Mawng Beds, and appears identical to specimens from the Upper Naungkangyi Beds.

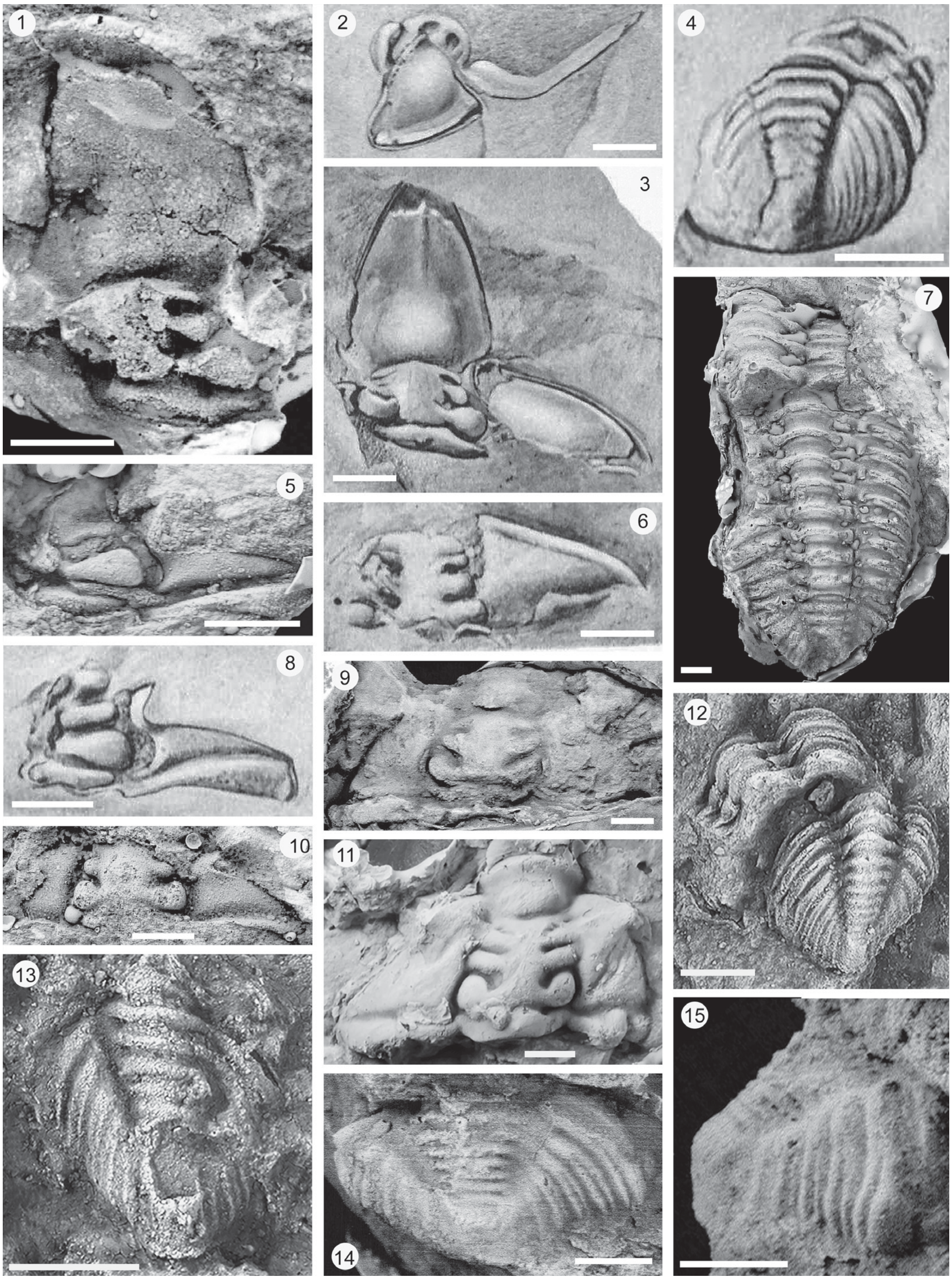

FIGURE 12. (1–6,8,10) *Reedocalymene unicornis* (Reed) from the Shihtien Formation (Darriwilian), Pupiao, Baoshan Prefecture, western Yunnan, China. 1–3. Cranidium (original and refigured of Reed 1917, pl. 8, fig. 10a,b), GSI 11913. 4. Pygidium (refigured from Reed 1917, pl. 8, fig. 13), GSI 11911?. 5. Partial cranidium (original of Reed 1917, pl. 8, fig. 12); GSI 11912?. 6. Partial cranidium (refigured from Reed 1917, pl. 8, fig. 11), GSI 11912?. 8. Partial cranidium (refigured from Reed 1917, pl. 8, fig. 12), GSI 11912?. 10. Partial cranidium (original of Reed 1917, pl. 8, fig. 11), GSI 11912?. (7) *Reedocalymene*? sp. (Reed), Thorax and pygidium (original of Reed 1917, pl. 8, fig. 14), GSI 11914, Shihtien Formation (Darriwilian); Pupiao, Baoshan Prefecture, western Yunnan, China. (9,11–15) *Neseuretinus* aff. *birmanicus* (Reed) from the Li-Lu and Pupiao formations (Katian). 9. Cranidium (lectotype, original of Reed 1906, pl. 5, fig. 27), GSI 8341, Kunkaw, northern Shan State, Myanmar. 11. Cranidium; CMC IP 91532, Pupiao, Baoshan Prefecture, western Yunnan, China. 12. Pygidium and partial thorax, CMC IP 91533, Pupiao, Baoshan Prefecture, western Yunnan, China. 13. Pygidium, CMC IP 91534, Pupiao, Baoshan Prefecture, western Yunnan, China. 14, 15. Pygidium (original of Reed 1915, pl. 8, fig. 5), GSI 11553, Loikok, northern part of Shan State, Myanmar, dorsal and right lateral views. Scale bars = 2 mm for 1–6, 8–10, 12–15; = 5 mm for 7, 11.

Subfamily Calymeninae

“Calymene” oldhami Reed, 1915

Figs 10.11,12

1915 *Calymene oldhami* sp. nov. Reed; p. 47–48, pl. 8, figs 10,11.

Material. Holotype: cranidium with partial thorax and hypostome in part and counterpart from Lower Naungkangyi Beds (probable Darriwilian) at Man-shio, Figs 10.11,12 (Reed, 1915, pl. 8 figs 11,10), GSI 11557,11558.

Discussion. A single small cranidium was the basis for this species. Reed (1915) illustrated both part and counterpart of this specimen, and this is followed herein. However, the specimens have deteriorated since their original description. For example, the hypostome is quite clearly shown on Brock’s illustration (Reed, 1915, pl. 8, fig. 11) and displays the median fork consistent with calymenid affinities; this is no longer clearly shown. They are included here for completeness. It is not possible to give a more precise generic assignment to this species, which is best regarded as a *nomen dubium*.

Family Cheiruridae Hawle & Corda, 1847

Placoparina Whittard, 1940

Type species. *Cryphaeus sedgwickii* M’Coy, 1849, Middle Ordovician, Builth, South Wales, U.K.

Placoparina? *dravidicus* (Reed, 1915)

Fig. 13.2

1915 *Cheirurus dravidicus*; Reed, p. 48, pl. 8, fig. 12.

Material. Holotype: pygidium from Lower Naungkangyi Beds (probable Darriwilian) at Man-shio, Fig. 13.2 (Reed, 1915, pl. 8, fig. 12), GSI 11559.

Discussion. The species was described by Reed (1915) on the basis of one pygidium; a cast from the counterpart of the type specimen is illustrated here. Reed’s illustrations show the tips of the three pairs of pygidial spines. The anterior pair is not noticeably more strongly developed than the other two pairs, as it is in cheirurines, and the posterior pair is also prominent in P.? *dravidicus*. Lane (1971) showed that pygidia were the most informative sclerite in cheirurids, and it seems improbable that *P.*? *dravidicus* is a cheirurine given its pygidial structure. *Eccoptochile* has a pygidium with three pairs of obtuse spines (type material of the type species in Horný & Bastl, 1970, pl. 14, fig. 1). The pygidium of *Placoparina* Whittard, 1940, is generally similar. However, the relatively obtuse lobes, and their marked fulcrum are more like those on *Placoparina* (Whittard, 1958) than *Eccoptochile,* and *dravidicus* is tentatively assigned herein to *Placoparina*. The identity of Reed’s species cannot confidently be resolved without further collections.

Hadromeros Lane, 1971

Type species. *Cheirurus keisleyensis* Reed, 1896. Keisley Limestone (Katian) Northern England.

Hadromeros? *submitis* (Reed, 1915)

Fig. 13.1

1915 *Cheirurus submitis* Reed, p. 49, pl. 8, figs 13,14.

Material. Lectotype (selected herein): cranidium from Upper Naungkangyi Beds (Katian), Lilu, northern Shan State, Myanmar, Fig. 13.1 (Reed, 1915, pl. 8, figs 13,14), GSI 11560.

Discussion. We illustrate here a cast taken from the lectotype, original of Reed (1915, pl 8. fig. 14). Only the cephalon is known of this species, which is only generally cheirurine, and invites comparison with those of many other species of similar age. It does, however, have very large, prominent but scattered tubercles on the cheeks and frontal lobe of the glabella. Many somewhat similar later Ordovician Chinese cheirurines have been assigned to the genus *Parisoceraurus* by Zhou & Zhen (2008) but these do not have such prominent tubercles. One species from the Pagoda Formation of Sichuan attributed (under open nomenclature) to *Hadromeros* by Zhou *et al.* (2016, pl. 14, fig. 14) does invite comparison with *H.*? *submitis* in showing very coarse, scattered tubercles over the fixed cheeks and forward part of the glabella, and may support a tentative assignment to *Hadromeros*. However, the Sichuan specimen and the type species of *Hadromeros* both show relatively long (tr.) glabellar furrows compared with H.? *submitis*, while the frontal glabellar lobe of the latter is relatively short (sag.) and wide. This structure seems to be unusual in cheirurids, and the distinctive glabellar lobation of the Myanmar species may indicate that it could belong to an undescribed genus, but without a pygidium this cannot be verified.

***Sphaerocoryphe* Angelin 1854**

Type species. *Sphaerocoryphe dentata* Angelin, 1854, Upper Ordovician, Sweden.

***Sphaerocoryphe* sp.**

Fig. 13.3

1906 *Sphaerocoryphe* sp. indet. Reed, p. 77, pl. 5, fig. 26.

Material. Cranidium from Upper Naungkangyi Beds (Katian) at Insang, northern Shan State, Fig. 13.3 (Reed, 1906, pl. 5, fig. 26), GSI 8340.

Discussion. A single and diminutive cranidium from the northern part of the Shan State was fully described by Reed (1906) and is refigured here for reference. The assignment to *Sphaerocoryphe* is supported, although the material is inadequate for specific comparison. Generally similar internal moulds have been figured from other Upper Ordovician strata (e.g. Dean, 1971).

Family Pterygometopidae Reed, 1905

***Yanhaoia* Zhou, Yuan & Zhou, 1998**

Type species. *Pterygometopus huayinshanensis* Lu, 1975, Middle Ordovician, Neichiashan Series, Sichuan, original designation.

Remarks. The generic classification of pterygometopids is not yet in a stable state. The species described below is placed in *Yanhaoia* because of its unusually large eyes combined with a relatively narrow axis.

***Yanhaoia wynnei* (Reed, 1915)**

Figs 13.4-9

1915 *Phacops* (*Pterygometopus*) *dagon*; Reed, p. 53–54, pl. 9, fig. 3.
1915 *Phacops* (*Pterygometopus*) *dagon* var. *wynnei*; Reed, p. 54–55, pl. 9, figs 7–15.

Material. Lectotype (selected herein): partial exoskeleton from Hwe Mawng, Fig. 13.8 (Reed, 1915, pl. 9, fig. 10), GSI 11576. Other material: incomplete cephalic shield from Hwe Mawng, Fig. 13.5 (Reed, 1915, pl. 9, fig. 7), GSI

11573; 2 incomplete cephalic shields from Mong Ha, Fig. 13.6 and unfigured (Reed, 1915, pl. 9, fig 11,8 respectively), GSI 11577, 11574 respectively; librigenae from Mong Ha, Nawng Yun, and Hwe Mawng (Reed, 1915, pl. 9, figs 9,13,14 respectively), GSI 11575, 11579, 11580 respectively;_pygidia from Hpawkyi and Nawng Yun, Fig. 13.7,9 (Reed, 1915, pl. 9, figs 12,15) GSI 11578, 11581. All specimens from Hwe Mawng Beds (Katian) at Hpakhi, Hwe Mawng, Mong Ha, or Nawng Yun.

Occurrence. Hwe Mawng Beds, type locality.

Description. Reed's (1915) general description can be supplemented by comments on particular features. The lectotype is distorted, but the cast shows the best surface detail. Other cephalic shields are internal moulds for the most part and as a result both the axial and glabellar furrows are deep and wide compared with their expression on the dorsal surface. The cephalic shield was originally somewhat less than twice as wide as long or narrower (Fig. 13.4). Three of the specimens displaying the glabella (Figs 13.4,6,8) show that the short S1 basal glabellar furrow is forked close to its base, and that the posterior fork outlines a basal lateral glabellar lobe –this is clearly seen on the lectotype and in Figs 13.4,6 (right). S2 is gently forwardly–directed, and the sigmoid form of gently backwardly-directed S3 is best shown in Fig. 13.6. Certain species of *Calyptaulax* show a similar structure. The anterior cranidial border is shown on the lectotype and on the cranidium Fig. 13.4, where it is narrow and rim-like, especially medially, and defined by a shallow furrow. Eyes are very large, half (exsag.) cranidial length (sag.), the deeply-defined palpebral rims flipped upwards from the level of the intraocular cheeks. The number of dorso-ventral lens files is not precisely determinable but certainly exceeds twenty, on high standing eyes. The free cheek illustrated by Reed (1915, pl. 9, fig. 9) suggests about 15 lenses per dorso-ventral file. The lectotype clearly shows deeply and coarsely pitted sculpture on the intraocular cheeks. The same sculpture extends on to the lateral parts of the fixed cheeks, but more feebly. There is no evidence of a genal spine. The incomplete six thoracic segments on the lectotype show the same kind of sculpture anterior to the deep and narrow epifacetal pleural furrows.

Well-preserved subtrapezoidal pygidium is best shown by cast from external mould (Fig. 13.9, right), 75% as long as wide. Eight (?faint ninth) axial rings, but internal mould (Fig. 13.7) would have displayed at least ten. Interpleural furrows much weaker than pleural furrows, defining six or seven ribs fading out on border, but again internal mould certainly shows more ribs extending to the posterior axial rings. Border is gently concave, most noticeably laterally. Posterior termination of pygidium behind axis shows a tendency to come to a median point.

Discussion. Reed (1915) distinguished *wynnei* as a subspecies of his taxon *Phacops (Pterygometopus) dagon* from the Upper Naungkangyi Beds. Quite apart from their stratigraphical separation, the cranidium of *dagon* differs from that of *wynnei* in having a distinct and wider cephalic border (sag.), relatively wider basal part of the glabella, and the first glabellar furrow S1 has less distinct distal bifurcation. It is regarded as belonging to a different genus. Hence *Pterygometopus dagon wynnei* is here elevated to species rank, and not regarded as closely related to *P. dagon dagon*. On the other hand, *wynnei* is also different from chasmopine pterygometopids with typically inflated and enlarged lateral glabellar lobes. It more closely resembles genera such as *Achatella*, which, according to Swisher *et al.* (2016), is a Baltic/Laurentian clade, and one with smaller eyes and generally distinct tuberculate sculpture, unlike *wynnei*. The presence of three pairs of well-developed lateral glabellar furrows is a plesiomorphic character. Small lateral basal glabellar lobes which become eliminated in more advanced species is pterygometopid, and exceptionally large eyes are typical of several taxa. Although the type species of *Yanhaoia* is not completely known and is older, *Y. wynnei* does share with it a narrow glabella posteriorly, and particularly large eyes, and, given the other similarities between Burmese and SW Chinese taxa, is assigned provisionally to this genus pending a revision of the whole group.

Family Dalmanitidae Vogdes, 1890

Dalmanitina Reed, 1905

Type species. *Phacops socialis* Barrande, 1846, Letná Formation (Berounian) Czech Republic

Dalmanitina? *dagon* (Reed, 1915)

Figs 13.10,11

1915 *Phacops (Pterygometopus) dagon*; Reed, pl. 9, figs 1–6, *non* fig. 3.

Material. Lectotype (selected herein): cephalic shield, original of Reed (1915) pl. 9, fig 1, GSI 11568. Pygidium, original of Reed (1915) pl. 9, fig. 5, GSI 11571. Upper Naungkangi Beds, Mangai. All specimens from Upper Naungkangyi Beds (Katian) at Man Ngai, northern Shan State.

Discussion. As considered above, Reed (1915) described a variety of what he termed *Phacops* (*Pterygometopus*) *dagon* as var. *wynnei*, which is regarded herein as a different taxon. The material of the nominate species is limited, and we have not been able to cast some of the original specimens, as they are fragile. The robust largest cranidium is selected as lectotype. A smaller cephalon illustrated by Reed (1915, pl. 9 fig. 2; Fig. 13.10) shows a well-defined anterior border, which was likely also present on the lectotype, though obviously broken medially in that specimen. Such a border is atypical of *Dalmanitina*, and may possibly suggest such genera as *Mucronaspis*, but without knowledge of the rest of the exoskeleton we prefer a provisional allocation to the older established genus. This border is extremely narrow on *wynnei*. The glabella of *dagon* is comparatively transverse anteriorly, and the bifurcation of the S1 is not so marked. Another small? cephalon illustrated by Reed (1915, pl. 9, fig. 3) is more like *wynnei* and is excluded from *dagon* here. The generic assignment of *D.*? *dagon* is equivocal, and the eyes are longer (exag.) than is typical for the dalmanitines according to Holloway (1981), a subfamily hard to delimit (Hammann & Leone, 2007). The species is placed provisionally in *Dalmanitina* pending a more comprehensive revision of Late Ordovician species.

Family Illaenidae Hawle & Corda, 1847

Remarks. Reed (1915, 1917) figured and described a number of *Illaenus* species under open nomenclature, mostly from cranidia alone. Illaenids are difficult to characterize even with the benefit of complete specimens, and almost impossible to determine from cranidia without other sclerites. Reed mostly compared his material with species known from the Russian platform, but there are few critical characters, and these specimens are figured here for the sake of completeness. The species in question are *Illaenus* aff. *schmidti, I.* cf. *esmarki* and *I.* aff. *caecoides* from the Shihtien Formation, Yunnan, and *I.* aff. *portlocki* from Hwe-Mawng, northern Shan State.

Parillaenus Jaanusson, 1954

Type species. *Illaenus fallax* Holm, 1882, Kullsberg Limestone, Upper Ordovician of Norway by original designation.

Parillaenus liluensis (Reed, 1915)

Figs 14.1–7

1915 *Illaenus liluensis* sp. nov.; Reed, p. 37–38, pl. 7, figs 4–7.
1915 *Holometopus wimani* sp. nov.; Reed, p. 39–40, pl. 7, figs 10–12.

Material. Lectotype (selected herein); cranidium from Nam Tu above Lilu, Fig. 14.3 (Reed, 1915, pl. 7, fig. 4), GSI 11536. Other Material: Complete dorsal skeleton from Lilu, Figs 14.5,6 (Reed, 1915, pl. 7, fig. 5), GSI 11537; cranidium from Lilu, Fig. 8.8 (Reed, 1915, pl. 7, fig. 12), GSI 115432; cranidia from Lilu, Fig. 14.1 and unfigured here (Reed, 1915, pl. 7, figs 10,11), GSI 11541-2 respectively; pygidium with partial thorax from Lilu, Fig. 14.4 (Reed, 1915, pl. 7, fig. 7), GSI 11538; hypostome from Lilu, Fig. 14.7 (Reed, 1915, pl. 7, figs 5,6), GSI 11537. All specimens from Upper Naungkangyi Beds (Katian) around Lilu. Reed (1915, p. 40) gives several localities for this species, but states in the plate legend that figured specimens of *Holometopus wimani* are from "1 mile north of Lilu" which must be the type locality for that species. The locality for the lectotype of *Illaenus liluensis* is "Right bank of Nam Tu above Lilu on path to Manping."

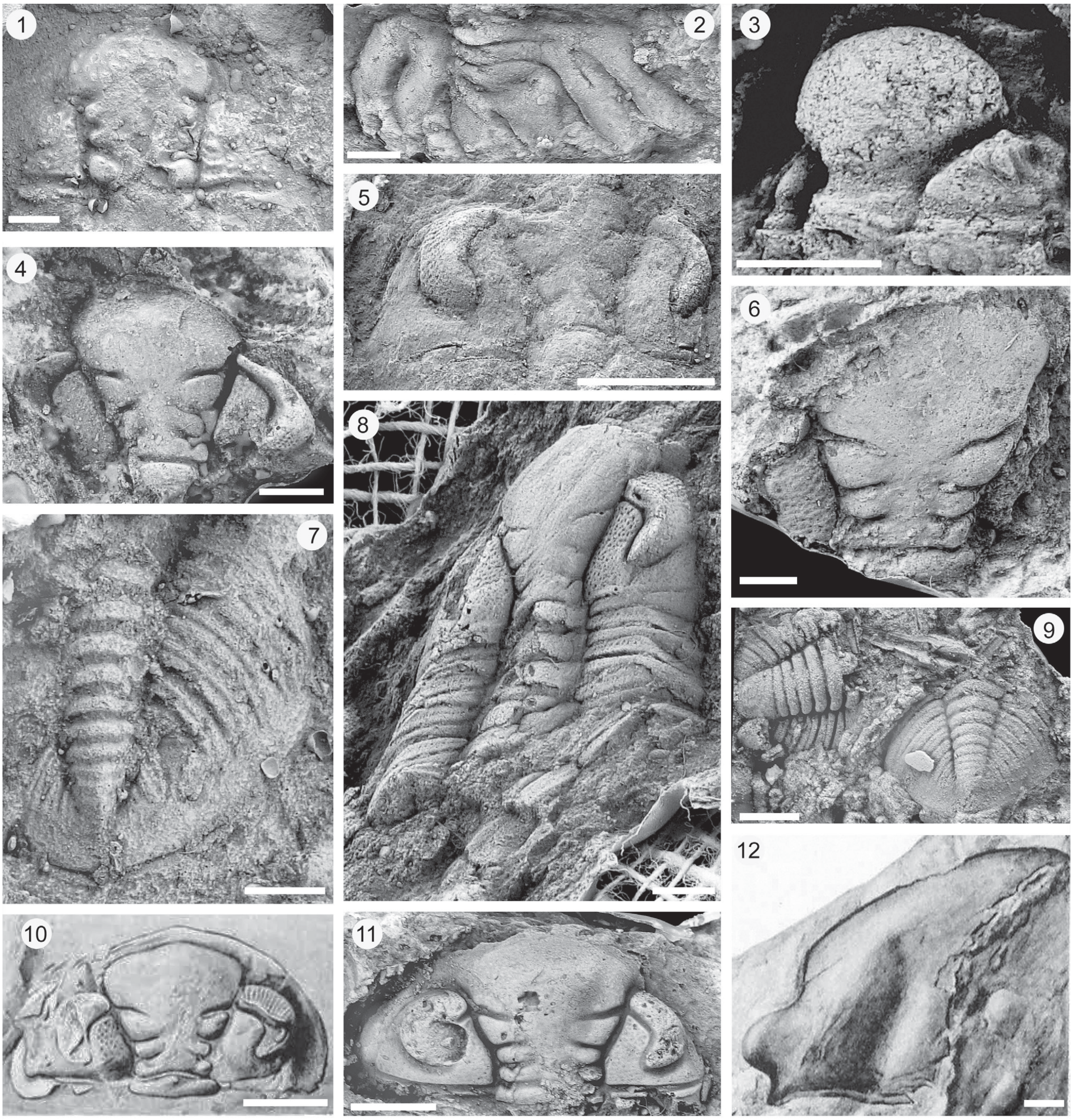

FIGURE 13. (1) *Hadromeros*? s*ubmitis* (Reed), Cranidium (original of Reed 1915, pl. 8, fig. 13), GSI 11560, Li-Lu Formation (Katian); Lilu, northern Shan State, Myanmar. (2) *Placoparina*? *dravidicus* (Reed), Pygidium (original of Reed 1915, pl. 8, fig. 12), GSI 11559, Lower Naungkangyi Beds; Mâ Shio, northern Shan State, Myanmar. (3) *Sphaerocoryphe* sp. (Reed), Cranidium (original of Reed 1906, pl. 5, fig. 26), GSI 8340, Naungkangyi Beds, Insang, northern part of Shan State, Myanmar. (4–9) *Yanhaoia wynnei* (Reed) from the Li-Lu Formation (Katian) and Hwe Mawng Beds (uppermost Katian), northern Shan State, Myanmar. 4. Cranidium (original of Reed 1915, pl. 9, fig. 3), GSI 11569, Mân-ngai. 5. Partial cranidium (original of Reed 1915, pl. 9 fig. 7), GSI 11573, Hwe Mawng. 6. Partial cranidium (original of Reed 1915, pl. 9, fig. 11), GSI 11577, Mong Ha. 7. Pygidium (original of Reed 1915, pl. 9, fig. 12), GSI 11578, Hpakhi. 8. Cranidium and thorax (cast from lectotype, original of Reed 1915, pl. 9, fig. 10), GSI 11576, Hwe Mawng. 9. Pygidium (original of Reed 1915, pl. 9, fig. 5), GSI 11571, Nawng Yu. (10–11) *Dalmanitina*? *dagon* (Reed) from the Li-Lu Formation (Katian) and Hwe Mawng Beds (uppermost Katian), northern Shan State, Myanmar. 10. Cranidium (refigured from Reed 1915, pl. 9, fig. 2), GSI 11568-11572, Mân-ngai. 11. Cephalon (original of Reed 1915, pl. 9, fig. 1), GSI 11568, Mân-ngai. (12) *Illaenus* sp. (Reed), Partial cranidium (refigured from Reed 1917, pl. 8, fig. 3), GSI 11906, Shihtien Formation (Darriwilian), Pupiao, Baoshan Prefecture, western Yunnan, China. Scale bar = 2 mm for 1, 3, 4, 6–9; = 5 mm for 2, 5, 10–12.

Discussion. Classification of illaenid trilobites is difficult and controversial, as with other trilobites tending to effacement. The species discussed here is placed in *Parillaenus* because of its similarity to *Parillaenus creber* Hammann, 1992. We are indebted to Sofia Pereira for pointing out that Hammann & Leone (2007, table, p. 109) revised this assignment to *Illaenus* ? *creber*. The proposition of *Parillaenus* in Jaanusson (1954, p. 574) was perfunctory, with the sole distinguishing character being the simple arcuate inner margin of the pygidial doublure. On the type species of *Parillaenus* the proportion of the dorsal exoskeleton occupied by the axis is greater than in the species from Myanmar (Jaanusson *in* Moore, 1959), but it is unclear whether this feature has systematic importance. There is no opportunity in this work to revise generic concepts of late Ordovician illaenids, and it is recognized that the assignment of Reed's *Illaenus liluensis* to *Parillaenus* could well change when a comparative study is carried out.

The casts made of small specimens of *Holometopus limbatus* Reed, 1915, are imperfect and do not add to Reed's description, while other, mostly larger specimens of *Illaenus Iiluensis* can only be refigured from Reed (1915). Reed directly compared the small cranidia with *Holometopus limbatus* Angelin, 1854, which subsequently became the type species of *Raymondaspis* Přibyl *in* Prantl and Přibyl (1949), a member of Styginidae Vogdes, 1890. The narrow, pestle-shaped glabella with well-defined occipital ring, but no other glabellar furrows, does resemble that of *R. limbata*, the type material of which was revised by Poulsen (1969). The Burmese species has a glabella that extends almost to the front of the cranidium, where the preglabellar furrow is effaced, while *R. limbata* has a distinct cranidial border. However, there are some characters that indicate that these smaller cranidia should not be referred to *Raymondaspis*. The width of the fixed cheeks (tr.) is much greater than in most species attributed to *Raymondaspis*, particularly posteriorly, and as far as can be judged the palpebral lobes are far out and relatively gently curved, rather than almost circular, and close to the glabella, as in well-preserved species attributed to *Raymondaspis*; the latter is also generally an early- to mid-Ordovician genus. Scandinavian species discussed by Nielsen (1995) indicate that *Raymondaspis* comprises a closely similar group of species of this age with a Baltic-Laurentian distribution. The larger specimens attributed to *Illaenus liluensis* by Reed (e.g. 1915, pl. 7, fig. 4) differ principally from the small ones attributed to *I. wimani* by the anteriorly effaced axial furrows and loss of the occipital furrow, and we believe that these differences are attributable to ontogeny. The two supposed species have been found together in a locality described by Reed (1915) as "1 Mile north of Lilu". Suggestive ontogenetic comparisons with the Burmese species can be drawn with several trilobites described by Hammann (1992) from the Ashgill (Katian) of Spain, including *Cekovia perplexa perplexa* Hammann and *Parillaenus creber* Hammann. As adults these species lack a cranidial border, have anteriorly effaced axial furrows, and wider fixed cheeks that are more convex (tr.) than in *Raymondaspi*s, and the palpebral lobes, placed far out, are not strongly curved. These are like *Illaenus liluensis*. However, smaller cranidia (Hammann, 1992, pl 4, fig. 4; pl. 9, figs 10-12) much more resemble *wimani* in their comparatively well-defined pestle shaped glabellas and visible occipital furrows. The small, nearly complete individual of *Illaenus liluensis* figured by Reed (1915, pl. 7, fig. 5) has a glabella more like that of *wimani* than the larger specimens attributed to *I. liluensis*. The mature specimens from Burma more closely resemble *Parillaenus creber* than *Cekovia*, notably in having wider cranidia and relatively large palpebral lobes as adults. The pygidium figured by Reed (1915, pl. 7, fig. 7), although not large, is very similar to that of *Parillaenus creber* Hammann in its very short (sag.) obtusely triangular pygidial axis. Hence our attribution to *Parillaenus* here, with the reservations noted above that the genus may well be further clarified. Zhou *et al*. (1984) and Zhou & Zhen (2008, p. 252) assigned some "Caradoc to early Ashgill" Chinese illaenids to *Parillaenus*, mostly fragmentary material previously attributed to *Illaenus*. The name *liluensis* appears before *wimani* in Reed's (1915) monograph and is therefore selected as the preferred name in this work. A second species of "*Holometopus*", *H. orientalis*, from the Hwe Maung Beds was erected by Reed (1915) on the basis of one, poorly preserved cranidium, refigured in Fig. 6.10. It does seem possible that this is a styginid with posteriorly positioned palpebral lobes, and this specimen is tentatively referred to *Stygina*.

Illaenus Dalman, 1827

Discussion. Reed (1915, 1917) described a number of *Illaenus* species from both the northern part of the Shan State and western Yunnan, mostly from fragmentary material. Attempts to make casts from the illustrated specimens were variably successful, but are included here for the sake of completeness. Since the classic works of Jaanusson (1954) and Bruton & Owen (1988) it has been clear that for meaningful systematics of *Illaenus* species it is necessary to know such features as the dorsal surface sculpture, particularly on the cephalon, details of muscle insertion areas, and such ventral features as the outline and extent of the pygidial doublure. Reed's specimens do not show most of these important features, and are not determinable in a modern way. Only one species, *Illaenus caecoides*, from Shihtien, Yunnan, was formally named. One cranidial fragment from Yunnan illustrated by Reed (1917, pl. 8, fig. 3) as *Illaenus* cf. *tauricornis* is not only incomplete, but also an internal mould, and very distorted. It is not worth re-illustrating. Two other fragmentary illaenids from Yunnan described by Reed (1917) as *Illaenu*s cf. *oblongatus* and *I.* aff *punctulosus*, were not successfully cast, and are not discussed in this paper. There is no reason to reproduce Reed's original remarks for the illaenids and only brief comments will be given here. All except *I. caecoides* were recorded by Reed under open nomenclature.

Illaenus caecoides **Reed, 1917**

Fig. 15.5

1917 *Illaenus caecoides* sp. nov.; Reed, p. 45–6, pl. 7, figs 9–10.

Material. Lectotype (selected herein): dorsal exoskeleton, Fig. 15.5 (Reed, 1917, pl. 7, fig. 9), GSI 11898. Additional type material: pygidium (Reed, 1917, pl. 7, fig. 10), GSI 11899. Both specimens from the Shihtien Formation (Darriwilian) at Banpo Village in Shidian County, western Yunnan.

Remarks. We were unable to make a satisfactory cast of the lectotype, and Reed's original illustration is reproduced here. Although the dorsal exoskeleton is complete it is much abraded. Reed (1917, p. 46) inferred that this was a blind species of "*Illaenus*" but we regard it as more probable that the abrasion of the dorsal surface has removed evidence of the facial sutures and the visual surfaces from a more typical illaenid. If this is so there are very few possible specific characters, and the species will not be recognisable until more collections are made from the type locality.

Illaenus **sp. 1.**

Figs 14.9,10

1915 *Illaenus* aff. *portlocki* Reed, pl. 7, figs 8,9.

Material. Pygidium from Hwe Maung Beds (uppermost Katian) at Hwe Maung, Fig. 14.9 (Reed, 1915, pl. 7, fig. 8), GSI 11539; cranidium from Upper Naungkangyi Beds at Man Ngai, Fig. 14.10 (Reed, 1915, pl. 7, fig. 9), GSI 11540.

Remarks. These two sclerites may not belong to the same species. The internal mould of the cranidium shows evidence of carrying raised transverse ridges anteriorly which may have been strong on the dorsal surface. The same feature is seen on *Illaenus* sp. 3 from Yunnan, but not enough is known of either species to prove they are the same species.

Illaenus **sp. 2**

Figs 14.8,11

1917 *Illaenus* aff. *schmidti* Nieszkowski 1857; Reed p. 46–7, pl. 7, figs 12,13.

Material. Incomplete cranidium, Fig. 14.11 (Reed, 1917, pl. 7, fig. 13), GSI 11902; pygidium, Fig. 14.8 (Reed, 1917, pl. 7, fig. 12), GSI 11901. Both specimens from Shihtien Formation (Darriwilian) at Banpo Village in Shidian County, Baoshan Prefecture, western Yunnan.

Remarks. This species is represented by an apparently crushed incomplete internal mould of a cranidium, and a pygidium in relief, also lacking the dorsal cuticle. The pygidium has broken to show the upper surface of the doublure, which is wide (sag.) and extends as far as the tip of the acutely triangular, short pygidial axis. A patch of the lower surface of the doublure with terrace ridges is also visible. This structure is typical of *Illaenus* sensu stricto, but little more can be said about this species.

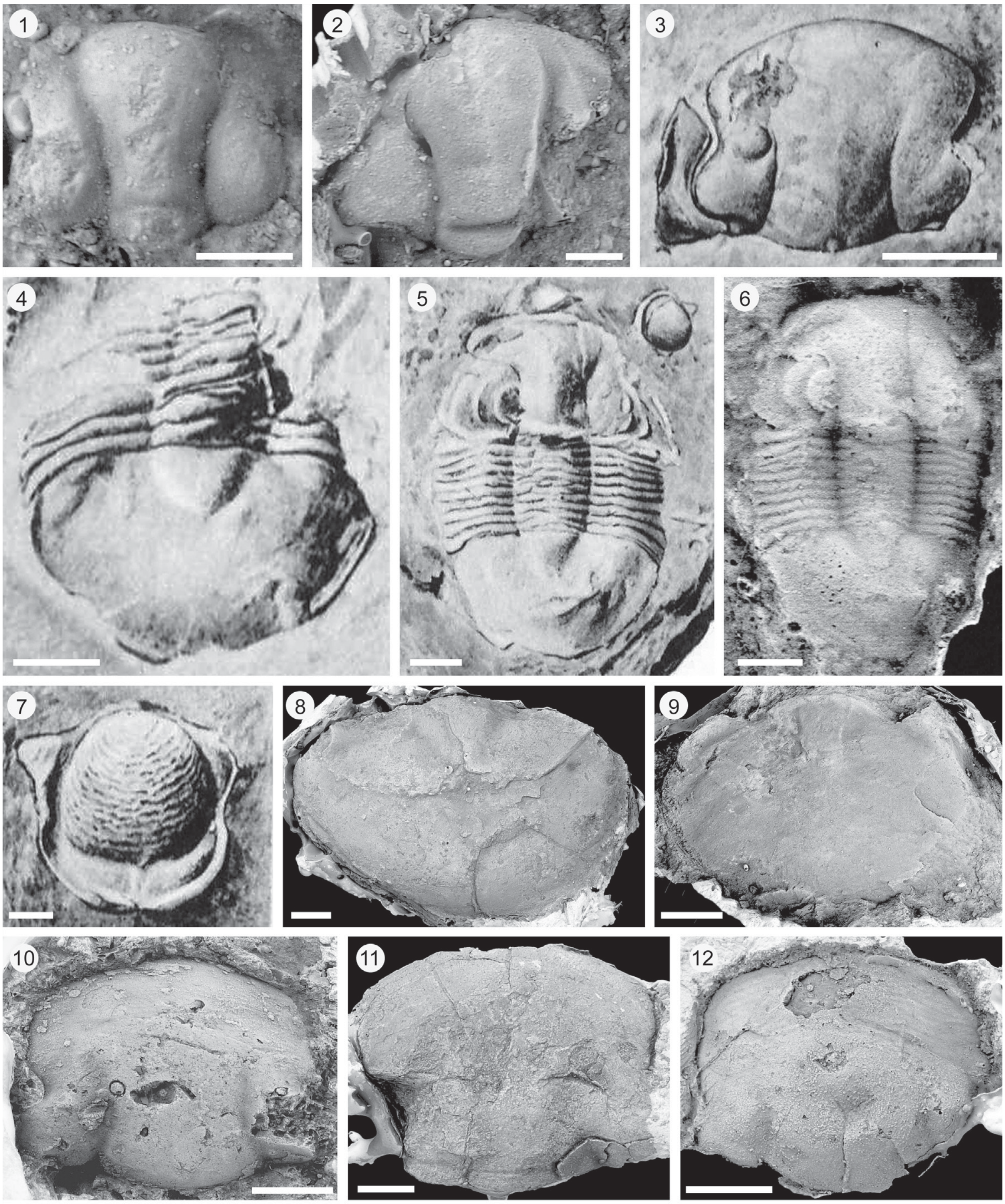

FIGURE 14. (1–7) *Parillaenus liluensis* (Reed) from the Li-Lu formation (Katian), Lilu, northern Shan State, Myanmar. 1. Cranidium (original of Reed 1915, pl. 7, fig. 10), GSI 11541. 2. Cranidium (original of Reed 1915, pl. 7, fig. 12), GSI 11543. 3. Cranidium (refigured from Reed 1915, pl. 7, fig. 4), GSI 11536. 4. Pygidium and partial thorax (refigured from reed 1915 Pl. 7, fig. 7), GSI 11538. 5. Complete specimen (refigured from Reed 1915, pl. 7, fig. 5), GSI 11537. 6. Complete specimen (original of Reed 1915, pl. 7, fig. 5), GSI 11537. 7. Hypostome (refigured from Reed 1915, pl. 7, fig. 6), GSI 11537. (8, 11) *Illaenus* sp. 2 (Reed) from the Shihtien Formation (Darriwilian, Banpo Village, Shidian County, Baoshan Prefecture, western Yunnan, China. 8. Pygidium (original of Reed 1917, pl. 7, fig. 12), GSI 11901. 11. Cranidium (original of Reed 1917, pl. 7, fig. 13), GSI 11902. (9, 10) *Illaenus* sp. 1 (Reed) from the Hwe Mawng Beds (uppermost Katian) and Li-Lu Formation (Katian), northern Shan State, Myanmar. 9. Cranidium (original of Reed 1915, pl. 7, fig. 8), GSI 11539, Hwe Mawng. 10. Cranidium (original of Reed 1915, pl. 7, fig. 9), GSI 11540, Mân-ngai. (12) *Illaenus* sp. 3 (Reed), Cranidium (original of Reed 1917, pl. 8, fig. 1), GSI 11905, Shihtien Formation (Darriwilian), Pupiao, Baoshan Prefecture, western Yunnan, China. Scale bar = 1 mm for 1, 2, 7; = 5 mm for 3, 8–12; = 2 mm for 4–6.

Illaenus sp. 3
Fig. 14.12

1917 *Illaenus* cf. *esmarki* Schloetheim; Reed pl. 7, fig. 14; pl. 8, figs 1,2.

Material. Cranidium, Fig. 14.12 (Reed, 1917, pl. 8, figs 1,2), GSI 11905; cranidium (Reed, 1917, pl. 7, fig. 14), GSI 11903. Both specimens from Shihtien Formation (Darriwilian) at Pupiao, western Yunnan.

Remarks. We refigure one of the two cranidia figured by Reed (1917). He figured a detail of an external mould showing strong terrace ridges on the front of the cephalic shield, and this feature is suggested also on the internal surface. There are few other features, and a critical determination is impossible without further material.

Family Telephinidae Marek, 1952

Phorocephala Lu, 1965

Type species. *Phorocephala typa* Lu, 1965, Siliangssu Formation, Liangshan, Shaanxi Province, China, by original designation.

Phorocephala mansuyi (Reed, 1917)
Figs 15.6-8

1917 *Bathyurus mansuyi* sp. nov.; Reed, p. 50–51, pl. 8, fig. 8.
1975 *Phorocephala mansuyi* (Reed); Lu, p. 189, 396.
1984 *Phorocephala mansuyi* (Reed); Zhou, Yin & Tripp, p. 24.

Material. Holotype: cranidium from Shihtien Formation (Darriwilian) at Pupiao, Baoshan Prefecture, Figs 15.6–8 (Reed, 1917, pl. 8, fig. 8), GSI 11848.

Discussion. The single example of this species is too fragile to cast successfully and we are obliged to re-use Reed's original (1917) illustration, with the cast showing preglabellar features. *Phorocephala* species vary with regard to the size of the eyes, though they are always prominent. In *P. mansuyi* the palpebral lobes are of relatively moderate size and posteriorly positioned, and in this regard this species is different from several other large-eyed Chinese species, such as *P. quadrata* Zhou & Dean, 1986; these last authors also reviewed other species that might be assigned to *Phorocephala*.

Phorocephala mansuyi was the first of these species to be named and therefore is potentially a senior name for a few other species with moderately-sized palpebral lobes. These include particularly the type species, *P. typa* Lu, 1965, and *P. shizipuensis* Yin *in* Yin & Li (1978) from Guizhou Province (see Zhou *et al.,* 1984). The former (see Lu, 1975, pl. 34, fig. 13) has a slightly wider cranidium than *P. mansuyi* and its preglabellar field is the same width (sag.) as the cranidial border, whereas on *P. mansuyi* the border is certainly narrower than the preglabellar field. One cranidium of *P. shizipuensis* illustrated by Zhou *et al.* (1984, fig. 5v) has similar general proportions to the type, and only known specimen of *P. mansuyi*, and on this specimen the border also seems to be convex rather than "upturned" (Zhou *et al.,* 1984, p. 24) as claimed from *P. shizipuensis*. However, the cranidial border does seem to be wider than on *P. mansuyi* on several specimens used to illustrate *P. shizipuensis* by Zhou *et al.* (1984). Since both *P. mansuyi* and *P. typa* are known from only one cranidium apiece there is no way of assessing variation in these species, and the eventual status of *P. mansuyi* will depend on new collections.

Family Lichidae Hawle & Corda, 1847

Metopolichas Gürich, 1901

Type species. *Metopias Hubneri* Eichwald 1842, Tallinna Limestone, Estonia. See Thomas & Holloway 1988, p. 214.

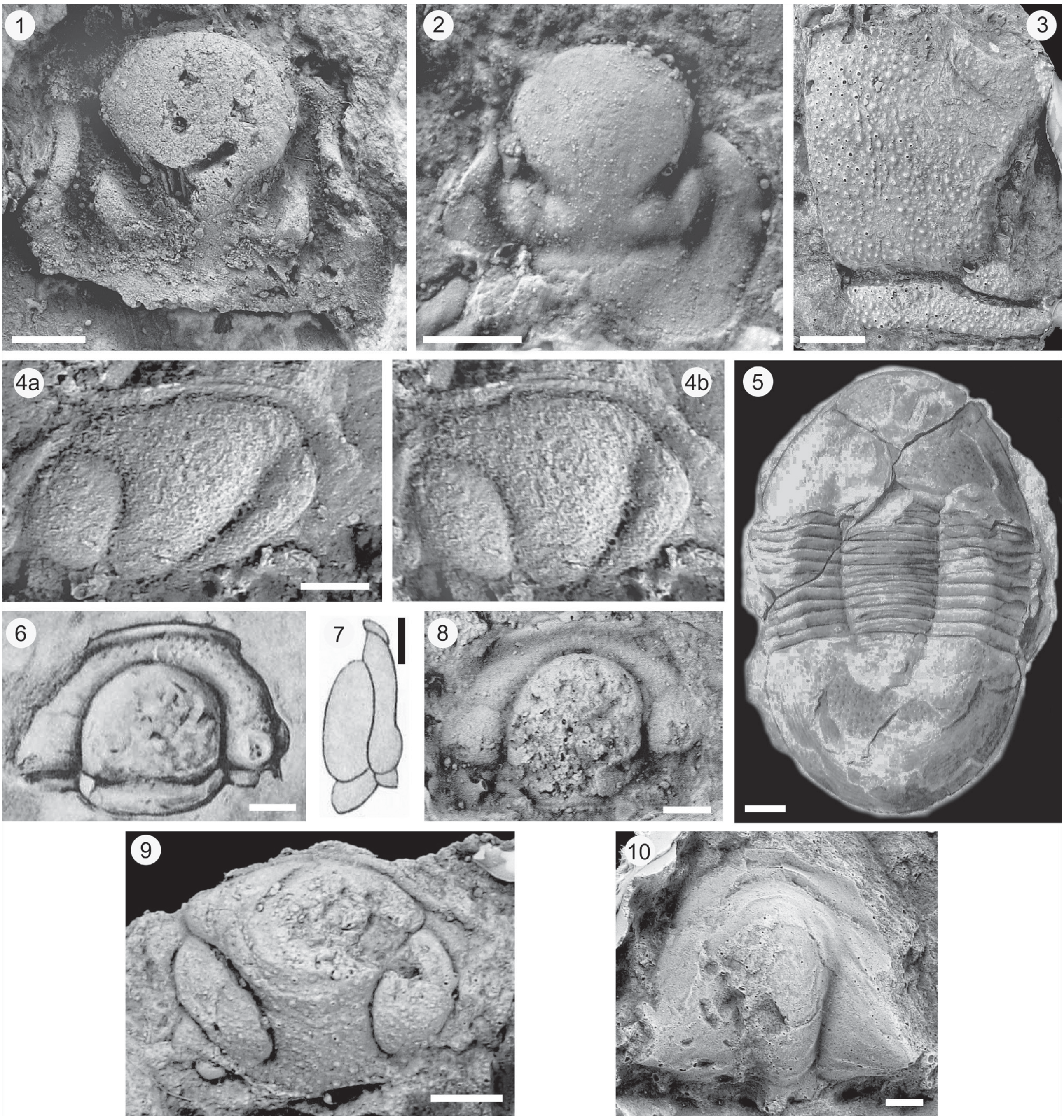

FIGURE 15. (1–4) *Metopolichas*? sp. 1 (Reed) from the Li-Lu and Kunlein formations (Katian), northern Shan State. 1. Hypostome (original of Reed 1915, pl. 7, fig. 15), GSI 11546, Mân-ngai. 2. Hypostome (original of Reed 1915, pl. 7, fig. 16), GSI 11547, Lilu. 3. Partial cranidium (original of Reed 1915, pl. 7, fig. 14), GSI 11545, Tâ-Pangtawng. 4a, b. Immature cephalon (original of Reed 1915, pl. 7, fig. 17), GSI 11548, Makmongshai, original and retrodeformation. (5) *Illaenus caecoides* Reed, Complete specimen (refigured from Reed 1917, pl. 7, fig. 9), GSI 11898, Shihtien Formation (Darriwilian), Banpo Village, Shidian County, Baoshan Prefecture, western Yunnan, China. (6–8) *Phorocephala mansuyi*, Cranidium (refigured and original from Reed 1917, pl. 8, fig. 7), GSI 11848, dorsal and lateral views, Shihtien Formation (Darriwilian), Pu-piao, Baoshan Prefecture, western Yunnan, China. (9) *Metopolichas* sp. 2 (Reed), Cephalon (original of Reed 1917, pl. 8, fig. 9), GSI 11910, Shihtien Formation (Darriwilian); Pupiao, Baoshan Prefecture, western Yunnan, China. (10) *Stygina*? sp. (Reed), Cranidium (original of Reed 1915, pl. 7, fig. 13), GSI 11544, Hwe Mawng Beds (uppermost Katian), Mong-Ha, northern part of Shan State, Myanmar. Scale bars = 2 mm for 1, 10; = 1 mm for 2, 4, 6–9; = 5 mm for 3, 5.

***Metopolichas*? sp. 1**
Figs 15.1–4

? 1915 *Lichas (Metopolichas)* aff. *verrucosus* Eichwald; Reed, p. 41–42, pl. 7, fig. 14.
1915 *Lichas* sp.; Reed, p. 42-43, pl. 7, figs 15–16.
1915 *Lichas* sp.; Reed, p. 43, pl. 7, fig. 17.

Material. Immature cephalon from Makmongshai, Fig. 15.4 (Reed, 1915, pl. 7, fig. 17), GSI 11458; partial cranidium from Tapangtawng, Fig. 15.3 (Reed, 1915, pl. 7, fig. 14), GSI 11545; two hypostomes from Man Ngai and Lilu, Figs 15.1,2 (Reed, 1915, pl. 7, figs 15,16 respectively), GSI 11547-8, respectively. All material from the Upper Naungkangyi Beds (Katian) at Lilu, Makmongshai, Man Ngai, or Tapangtawng, northern Shan State.

Discussion. We are indebted to comments from Dr. A. T. Thomas (written communication 2019) who commented that the small cranidium is not sufficiently complete to determine as to genus as the posterior is not preserved. However, the hypostomes are comparatively well preserved, and a most similar to those described from *Metopolichas* spp. to which genus this fragmentary material is tentatively assigned.

***Metopolichas* sp. 2**
Fig. 15.9

1917 *Lichas (Metopolichas) celorhin* Angelin; Reed, p. 51, pl. 8, fig. 8.
1917 *Lichas (Metopolichas)* aff. *verrucosus* Eichwald; Reed, p. 52, pl. 8, fig. 9.

Material. Small cranidium from Pupiao, Fig. 15.9 (Reed, 1917, pl. 8, fig. 9), GSI 11910; cranidial fragment from Banpo Village, Shidian County (Reed, 1917, pl. 8, fig. 8), GSI 11909. Both specimens from Shihtien Formation (Darriwilian).

Discussion. The cranidium is sufficiently well-preserved to show details of the lateral glabellar lobes. Dr. A.T. Thomas informs us (written communication 2019) that it is probably referable to *Metopolichas*, and is similar to the cranidium of such species as *M. contractus* McGregor 1963 (Thomas & Holloway, 1988, pl. 11, fig. 234). Without further sclerites known it should remain under open nomenclature.

Acknowledgements

We thank officers of the Repository Division, Geological Survey of India, Kolkata, for kind permission to observe and cast specimens in their care and Ajoy K. Moitra for recently checking specimen numbers there. Cameron Schwalbach of the Cincinnati Museum Center helped in repositing additional material. Leonid Popov for consulting on brachiopods and stratigraphic ages. NERC grant GR3/10717 enabled Fortey and Hughes to visit Kolkata. Richard Fortey gratefully acknowledges receipt of a Royal Society International Exchange "Flexigrant" IES\R2\170037 for a visit to Riverside. Additional funding for our work on Sibumasu is from the US National Science Foundation grant EAR-1849963 to Hughes. We thank Mansoureh Ghobadi Pour for comments on taxon distribution and a careful review, and Sophia Pereira for many useful comments on the manuscript. Alan T. Thomas is thanked for advice on lichids. Shanchi Peng and Huilin Luo are thanked for guidance in the field in Baoshan. Hughes also acknowledges receipt of Fulbright Academic and Professional Excellence Award 2019 APE-R/107 and the Indian Statistical Institute, Kolkata for hosting him. This study is a contribution towards IGCP 668 "Equatorial Gondwanan History and Early Palaeozoic Evolutionary Dynamics" and IGCP 735 "Rocks and the Rise of Ordovician Life".

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