Permian gastropods from the Tak Fa Limestone, Nakhon Sawan, Northern Thailand

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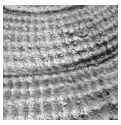

A silicified Middle Permian (Wordian) gastropod fauna is reported from the Tak Fa Limestone from Northern Thailand. It is the first diverse Permian gastropod fauna known from Thailand. The fauna comes from shallow water carbonates that are rich in fusulinids, sponges and calcareous algae. Forty gastropod species are reported, among them 17 nominate species and 23 species in open nomenclature. Thus, this fauna represents one of the richest Permian gastropod faunas known from Southeast Asia. Twelve species and one genus are new to science (all new taxa authored by Nützel & Ketwetsuriya). The new genus is *Takfaia*. The new species are *Pharkidonotus khaonoiensis*, *Khumerspira thailandensis*, *Baylea*? *umbilicata*, *Takfaia kuesi*, *Glabrocingulum magnum, Knightinella ornata*, *Anomphalus lateumbilicatus*, *Yunnania pulchra*, *Microdoma carinata*, *Trachydomia takhliensis*, *Goniasma tricarinata* and *Cambodgia acuminata*. The gastropod fauna is dominated by typical Late Palaeozoic cosmopolitan genera with bellerophontoids and pleurotomariines being most abundant. • Key words: Gastropoda, Late Palaeozoic, Permian, Thailand, silicification, diversity.

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The present contribution reports and describes a Middle Permian (Wordian) gastropod fauna from the Tak Fa Formation of the Saraburi Group, Nakhon Sawan, North Thailand (informally known as Tak Fa Limestone). The Tak Fa Limestone is fossiliferous and yields a diverse Permian invertebrate fauna. The present gastropod fauna has previously been reported in a preliminary note by Ketwetsuriya *et al.* (2014) based on silicified shells weathering out at the surface of calcareous rocks. Meanwhile, the carbonate samples have been dissolved and numerous silicified gastropod shells have been recovered. With 40 species, the present fauna is one of the most diverse Permian gastropod faunas from Southeast Asia supplementing our knowledge of Middle Permian gastropod distribution in this region considerably.

Previously, there have been few reports or mentions on Permian gastropods from Thailand. Grant (1976) studied Permian brachiopods from South Thailand and mentioned the presence of platyceratids and pleurotomarioids. Waterhouse (1982) studied an early Permian invertebrate fauna from the Kaeng Krachan Group and mentioned presence of the gastropod genus *Peruvispira*. Sone (2010) reported the species *Magnicapitatus huazhangae* from the Middle Permian (Guadalupian) of East Thailand and this is the only Permian gastropod species described from Thailand (type locality) to this point.

Geological setting

The Permian limestones yielding the studied gastropods are exposed along Khao Noi hill, located in Takhli district, Southeast of Nakhon Sawan province, *ca* 80 km south of Nakhon Sawan City, Northern Thailand, 15° 18´ 51.801˝ N, 100° 26´ 30.358˝ E (Fig. 1). The Permian limestone succession in the study area is part of the Tak Fa Formation of the Saraburi Group. The Tak Fa Formation was named by Nakornsri (1977, 1981) who published a geological map of the Amphoe Ban Mi area. The

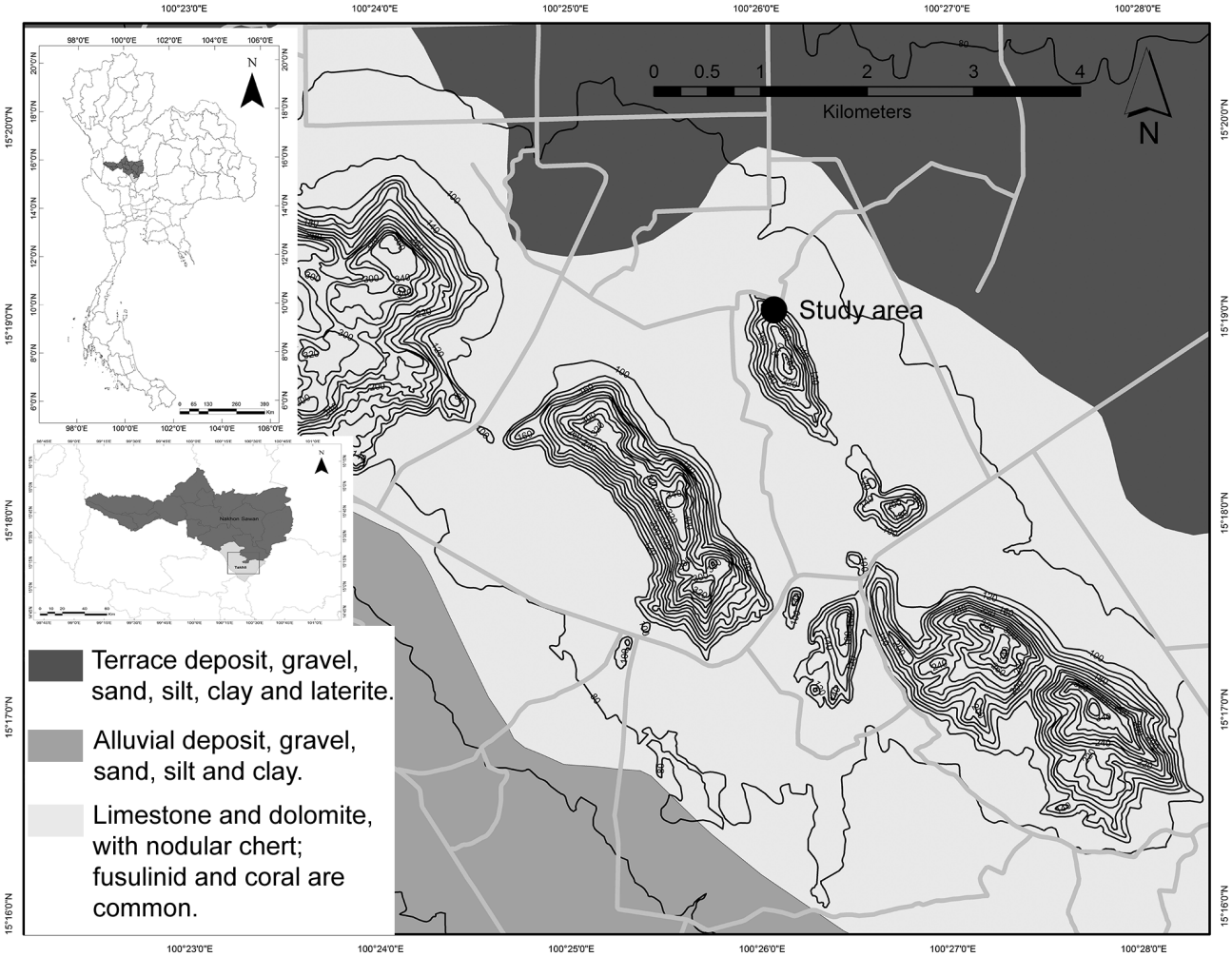

Figure 1. Geological map and locality of the studied section that produced the silicified gastropods at Khao Noi hill, Takhli district, Nakhon Sawan province, North Thailand.

Figure 2. The fossiliferous limestone (middle layer) from which the studied samples were collected.

Tak Fa Formation comprises limestone interbedded with argillaceous limestone, mudstone and dolostone. Parts of the limestone succession yield chert nodules and are fossiliferous. The invertebrate fossils in this formation comprise fusulinids, corals, brachiopods, gastropods, bryozoans and others.

The Tak Fa Formation is the part of Khao Khwang platform (Wielchowsky & Young 1985, Ueno & Charoentitirat 2011) located at the western margin of the Indochina Terrane (Metcalfe & Sone 2008). Fusulinids indicate a Yakhtashian or Artinskian (late Early Permian) to Midian or Capitanian (late Middle Permian) age for the fusulinoidean limestones of the Tak Fa Limestone in the East of the Nakhon Sawan province (Napradit 2005). In the studied section yielding the gastropods, the Tak Fa Limestone has a Wordian age.

The exposed section of fossiliferous limestones of the Tak Fa Formation yielding the studied gastropods has a thickness of approximately 35 meters. It consists of thick to very thick-bedded, light grey (lower part) to dark grey (upper part) limestones. The beds dip with 30° to the West. The lower part of the section is dominated by thick-bedded

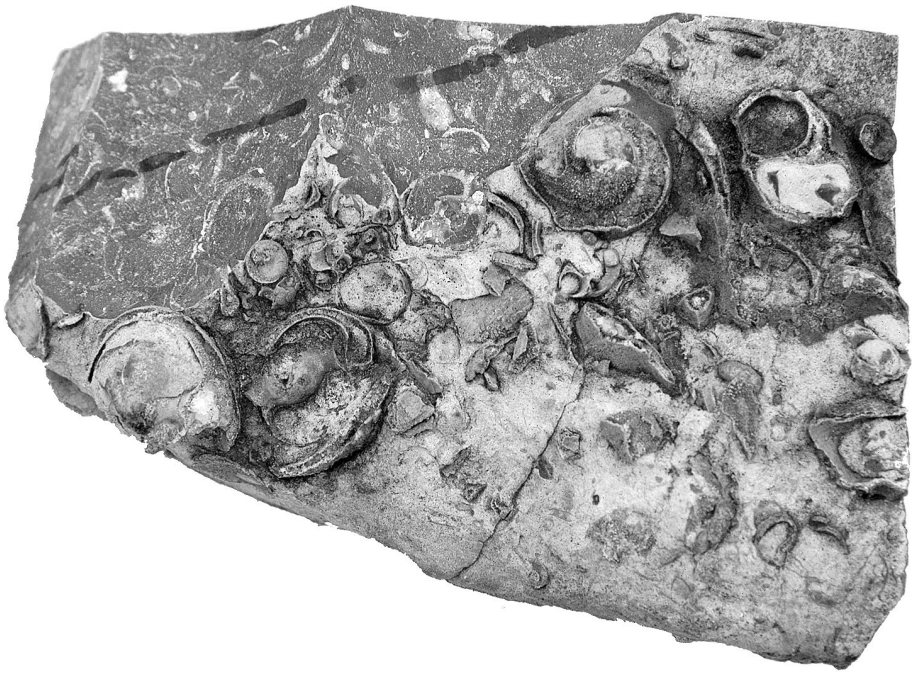

Figure 3. Limestone block as an example for preservation; silicified shell material weathered out from a grey, micritic limestone; width *ca* 15 cm.

packstones. Fusulinids, rugose corals, bryozoans, crinoid stems and gastropods are commonly found (only few samples were collected from this bed). The middle part of the sections consists of thick-bedded wackestones. The upper part of the section is composed of very thick-bedded, grey to dark-grey packstones with black chert nodules at the base and locally interbedded with laminated dark-grey shale (Fig. 2). Most of the studied samples were collected from the upper beds. In these beds, gastropods and fusulinids are abundant. Silicified gastropods weather out from the rock (Figs 2, 3). In the field, colonial and solitary rugose corals, brachiopods, crinoid stems and sponges could be observed.

Materials and methods

Samples were preferentially taken where silicified gastropods weathered out from the rock. The samples yielding the silicified fauna were collected by the first author in 2010, 2013 and 2015. They were dissolved in formic acid at the Bayerische Staatssammlung für Paläontologie und Geologie in Munich, Germany. Most samples came from two stratigraphic layers at the north of an isolated hill (Fig. 1). After etching, the material was sieved under rinsing water at a mesh size of 0.5 mm. All fossils including the gastropods were picked from the washed residues. Gastropods were sorted according to species and samples. Representatives of each gastropod species and some other species were whitened with ammonium-chloride and documented with microphotography

Biota in the studied samples

Most of the samples that were dissolved were very fossiliferous and produced abundant silicified fossils. However, most of the fossil material consists of unidentifiable shell fragments. Remains of calcareous algae such as codiaceaens (Fig. 4A) and the dasycladacean *Mitzia* sp. (Fig. 4B) were abundant in some of the gastropod-rich samples. Silicified fusulinids are abundant in most of the samples (Fig. 4C) and thin-sections showed that fusulinids are present in rock-forming quantities. The presence of these algae and foraminiferans suggest a tropical shallow water environment. The samples also yielded rather large sclerites probably deriving from sponges (Fig. 4D, E). Among other invertebrates, gastropods are by far the most diverse and abundant group. They are commonly fragmented but more or less complete specimens are also present. The strong dominance of gastropods is remarkable but it must be taken into account that gastropod-rich rocks were sampled preferentially in the field. The samples also yielded few small articulate brachiopods (Fig 4F, left), scaphopods (Fig. 4F, right), polyplacophoran plates (Fig. 4G), small nuculoid bivalves (Fig. 4H, I) and other bivalves (Fig. 4J, K). The few present brachiopods and bivalves have commonly attached valves indicating that the fauna is basically autochthonous and not transported.

A quantitative census of the fossils in the studied samples is difficult because of the high degree of fragmentation and the problematic preservation of many of the fossils. However, it seems clear that the fauna is very diverse with a low dominance. A comprehensive study

on the diversity of the Tak Fa fauna will be attempted at a later point.

General remarks on the gastropod fauna

As mentioned, except for fusulinids, gastropods are the most abundant and diverse group in the present collection from the Tak Fa Limestone. According to the present genera, it is a typical Late Palaeozoic gastropod fauna encompassing cosmopolitan genera such as *Euphemites*, *Pharkidonotus*, *Glabrocingulum*, *Anomphalus*, *Yunnania*, *Microdoma*, *Trachydomia*, *Goniasma* and others. Other genera seem to be restricted to Southeast Asia according to the current state of knowledge. Although a complete census is difficult because of the poor preservation and fragmentation of many of the gastropods, it is obvious that bellerophontoids, pleurorotomariines and trochoids represent the most abundant groups with *Warthia* and other bellerophontoids as well as *Glabrocingulum magnum* sp. nov. being most abundant. This dominance of basal gastropod clades is certainly a Palaeozoic aspect of this fauna. This separates it from the diverse fauna of Perak, Malaysia and the Japanese Akasaka Limestone in which caenogastropods play a much larger role (Batten 1985, Nützel & Nakazawa 2012). As mentioned, the strong gastropod dominance in the studied samples is a remarkable aspect of this fauna but the picture is biased because rocks with gastropods were preferentially sampled. Further studies are needed to test whether gastropod dominance is a real phenomenon in the Tak Fa Limestone.

Preservation

The silicification is relatively coarse so that certain morphological features are obscured *e.g.*, the growth line pattern is not visible in most of the specimens. This represents a major handicap for identification, especially in pleurotomariines and muchisoniines in which presence and position of the selenizone or sinus is of great diagnostic relevance. Protoconchs are not or not sufficiently preserved in the present collection. As a consequence open nomenclature was used for many species. On the other hand, preservation was sufficiently good to assign specimens to genera and to characterize several species including new taxa.

Repository

The studied material is housed in the Bayerische Staatssammlung für Paläontologie und Geologie (Bavarian State Collection for Palaeontology and Geology) in Munich, Germany under the general repository number SNSB-BSPG 2014 XI. Some of the paratypes are housed in the Chulalongkorn University, Museum of Zoology, Bangkok, Thailand (CUMZ).

Systematic palaeontology
by Alexander Nützel & Chatchalerm Ketwetsuriya

The classification used herein is based on Wenz (1938–1844), Knight *et al.* (1960), Bouchet *et al.* (2005) and Bouchet *et al.* (in review).

Class Gastropoda Cuvier, 1795
Subclass Amphigastropoda Simroth, 1906
Order Bellerophontida Ulrich & Scofield, 1897
Superfamily Bellerophontoidea McCoy, 1852
Family Euphemitidae Knight, 1956

Genus *Euphemites* Warthin, 1930

Type species. – *Bellerophon urii* Fleming, 1828, Great Britain, Carboniferous.

***Euphemites graffhami* Moore, 1941**
Figure 5F–L

1941 *Euphemites graffhami* sp. nov.; Moore, p. 142, pl. 2, figs 1–5.

Material. – Two specimens, SNSB-BSPG 2014 XI 58, 105.

Description. – Shell bellerophontiform, anomphalous, with geniculate curvature of body whorl in lateral view; larger specimen 30 mm long, 28 mm wide, 25 mm thick; first geniculation in aperture, second on opposite side; shell ventrally flattened between geniculations and rounded dorsally; body whorl smooth, probably covered with secondary shell deposits, neither growth lines, selenizone or slit observable; dorsal part of body whorl with broad shallow central furrow; inductura inside aperture with about 10 spiral lirae; aperture strongly bent kidney-shaped in transverse section with steep lateral lips, rounded anterior lip with central sinus (where shallow median furrow is situated) and a rounded triangular inner lip formed by the previous whorl; lateral lips joining body whorl with an U-shaped sinus in lateral view.

Remarks. – Despite the differences in age and region, we assign the present material to *Euphemites graffhami* Moore, 1941 from the late Pennsylvanian of Kansas, USA because there are no obvious morphological differences between our material and Moore's (1941) type material as illustrated by this author. The geniculation was not mentioned in

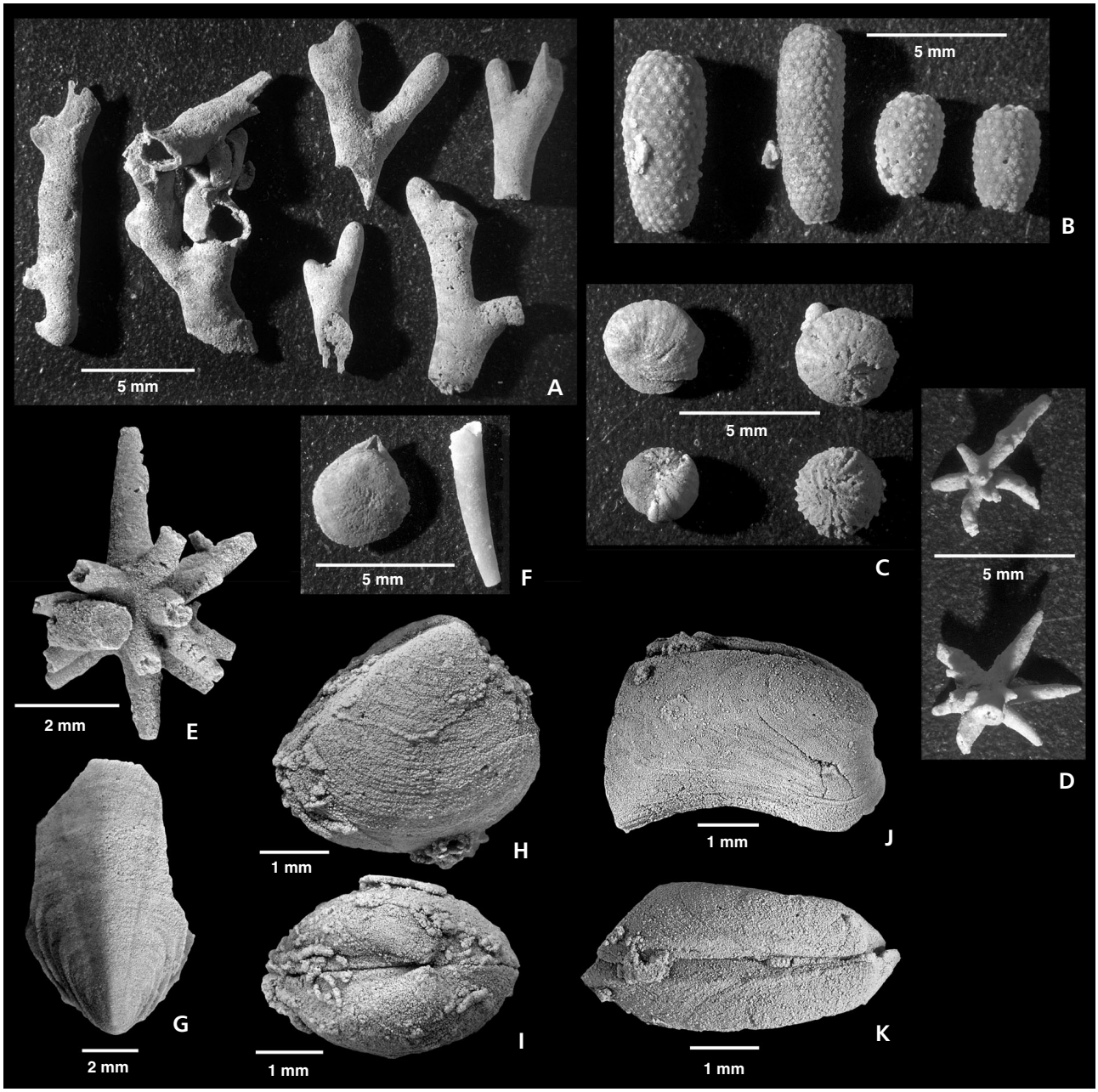

Figure 4. Examples for silicified fossils other than gastropods from the studied samples. • A – codiacean algae. • B – fragments of the dasycladacean algae *Mitzia* sp. • C – poorly preserved foraminiferans (fusulinids). • D, E – sclerites, probably deriving from sponges. • F – small articulate brachiopod (left) and scaphopod (right). • G – plate of polyplacophoran. • H, I – small nuculoid bivalve, SNSB-BSPG 2014 XI 118. • J, K – bivalve, SNSB-BSPG 2014 XI 111.

Moore's description but becomes obvious from his illustrations (Moore 1941, figs 4b, 5b). As pointed out by Yochelson (1960), there are not many distinctly geniculated species of the genus *Euphemites*. *Euphemites imperator* Yochelson, 1960 from the Permian of Texas is the most similar species. However, in this species, the spirally ornamented inductura extends much farer outside the aperture. Moreover, the shell *Euphemites graffhami* is much more flattened ventrally. *Euphemites graffhami* is similar to *E. nodosocarinatus* (Hall, 1858) from the Pennsylvanian of the USA as reported by Kues & Batten (2001). However, this species has many more inductural lirae and according to Yochelson (1960), it has nodes near the selenizone as is also the case in *E. callosus* (Weller, 1930).

Genus *Warthia* Waagen, 1880

Type species. – *Warthia brevisinuata* Waagen, 1880, Permian, India.

***Warthia* cf. *brevisinuata* Waagen, 1880**
Figure 5A–E

cf. 1880 *Warthia brevisinuata* sp. nov.; Waagen, p. 161, pl. 15, fig. 6.
2014 *Bellerophon* sp. 1; Ketwetsuriya *et al.*, p. 139, pl. 1, figs a, b.

Material. – SNSB-BSPG 2014 XI 2, 27 and several other specimens.

Description. – Shell globular bellerophontiform, anomphalous; larger illustrated specimen 4.9 mm long, 5.3 mm wide, 4.3 mm thick (SNSB-BSPG 2014 XI 27); whorl profile and anterior lip evenly rounded; whorls smooth, probably covered with secondary shell layers; whorls kidney-shaped, low in transverse section.

Remarks. – Several relatively small smooth bellerophontoids representing the genus *Warthia* are present in this collection. Of the numerous described Late Palaeozoic *Warthia* species, *Warthia brevisinuata* Waagen, 1880 from the Permian of the Salt Range, Pakistan seems to be most similar. But because of the preservation and the relatively uncharacteristic shell morphology, a safe identification is impossible.

***Warthia* sp.**
Figure 5M–O

Material. – One specimen, SNSB-BSPG 2014 XI 106.

Remarks. – This shell representing the genus *Warthia* (31 mm long, 32 mm wide) resembles the much smaller specimens of *Warthia* cf. *brevisinuata* as described above but has callus (inductural) pads on the umbilical region and on the lateral lips. It is possible that these smaller specimens representing *Warthia* cf. *brevisinuata* are juveniles and are conspecific with the present mature shell.

Family Bellerophontidae McCoy, 1852
Subfamily Bellerophontinae McCoy, 1852

Genus *Bellerophon* de Montfort, 1808

Type species. – *Bellerophon vasulites* de Montfort, 1808, Devonian, Germany.

***Bellerophon* sp.**
Figure 6A–E

Material. – Three specimens, SNSB-BSPG 2014 XI 49, 65 (fragment), 107 (fragment).

Description. – Bellerophontid with deeply umbilicated shell; whorls low, broad in transverse section ornamented with distinct collabral lirae separated by wider interspaces; selenizone narrow, bordered by undulating lirae, with distinct lunulae.

Remarks. – Although only fragments are present, the characteristic selenizone and ornament suggest the presence of an additional bellerophontid species in the Tak Fa fauna.

***Bellerophon*? sp.**
Figure 6F, G

Material. – One specimen, SNSB-BSPG 2014 XI 60.

Remarks. – This anomphalous bellerophontoid shows growth lines and a faint spiral striation. It is 24 mm long, 28 mm wide and 26 mm thick and seems to have a slight depression at the supposed position of the selenizone. The anterior lip is evenly rounded. Preservation is insufficient for a taxonomic assignment. It could represent the genera *Bellerophon*, *Retispira* or *Warthia* with outer shell layers peeled off.

Genus *Pharkidonotus* Girty, 1912

Type species. – *Bellerophon percarinatus* Conrad, 1842; Pennsylvanian, USA.

***Pharkidonotus khaonoiensis* sp. nov.**
Figure 7A–K

2014 *Bellerophon*? sp. 2; Ketwetsuriya *et al.,* p. 139, pl. 1, fig. c.

Locus typicus. – Khao Noi hill, Takhli district, Southeast of Nakhon Sawan province, *ca* 80 km south of Nakhon Sawan City, Northern Thailand, 15° 18´ 51.801˝ N, 100° 26´ 30.358˝ E (Fig. 1).

Stratum typicum. – Tak Fa Formation of the Saraburi Group, Middle Permian, Wordian.

Material. – Holotype: SNSB-BSPG 2014 XI 88; paratypes: SNSB-BSPG 2014 XI 4, 46, 59, 61, CUMZ 7001.

Etymology. – After the Khao Noi hill at which the studied gastropod material was found.

Description. – Shell bellerophontiform, globose, longer than wide, anomphalous; holotype 30 mm long, 23 mm

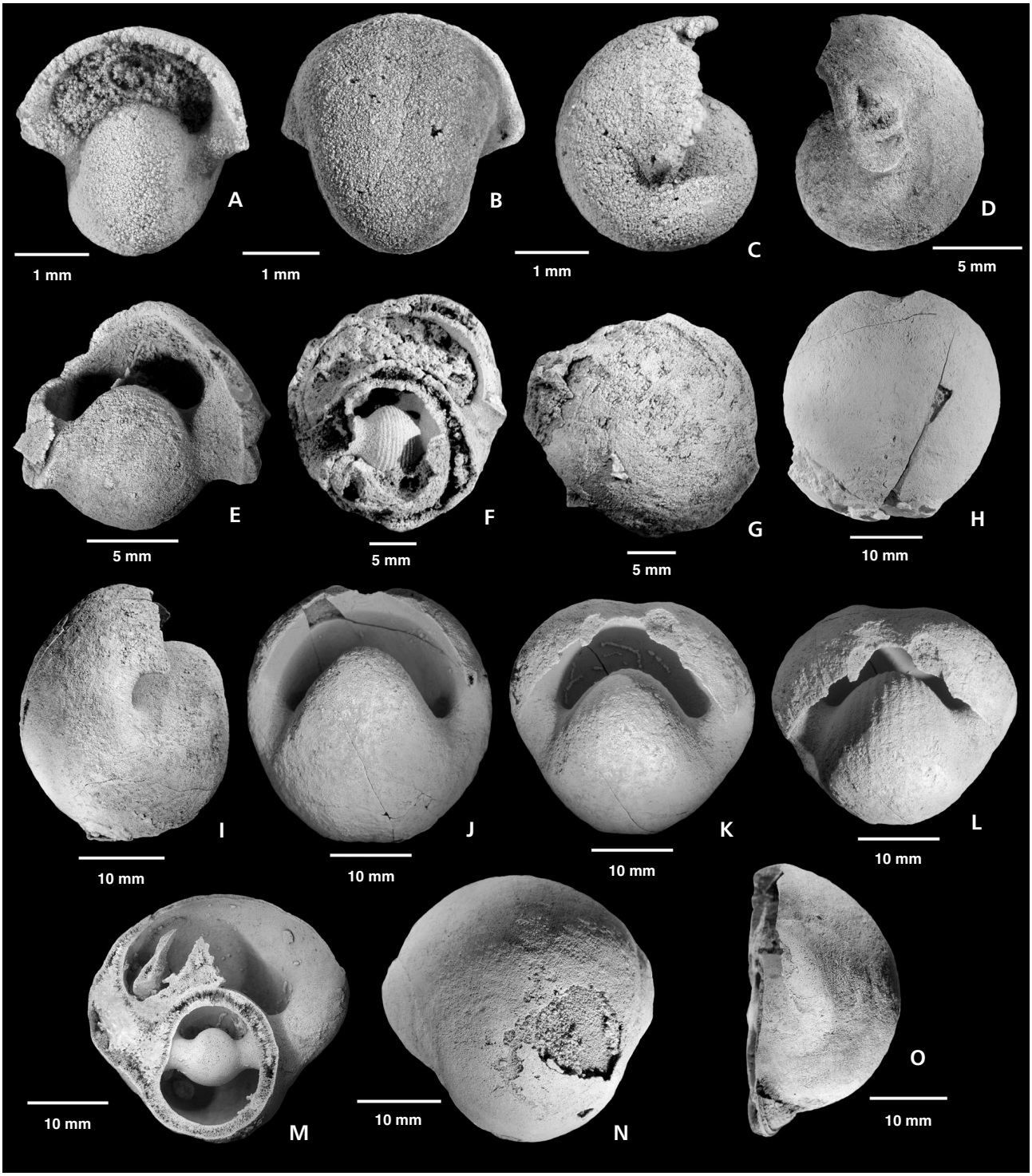

Figure 5. A–C – *Warthia* cf. *brevisinuata* Waagen, 1880, SNSB-BSPG 2014 XI 2. • D, E – *Warthia* cf. *brevisinuata* Waagen, 1880, SNSB-BSPG 2014 XI 27. • F, G – *Euphemites graffhami*, SNSB-BSPG 2014 XI 58. • H–L – *Euphemites graffhami*, apertural views at different angles to show spiral lirae within aperture, SNSB-BSPG 2014 XI 105. • M–O – *Warthia* sp., SNSB-BSPG 2014 XI 106.

wide, 26 mm thick; whorl profile round in lateral view; whorls with pronounced, steeply sided median crest with selenizone; borders of selenizone undulating on last part of the body whorl; outer lip as reflected by growth lines sickle-shaped; aperture kidney-shaped in transverse section with rounded anterior lip, U-shaped at crest; inductura extending from umbilici over some area outside the aperture.

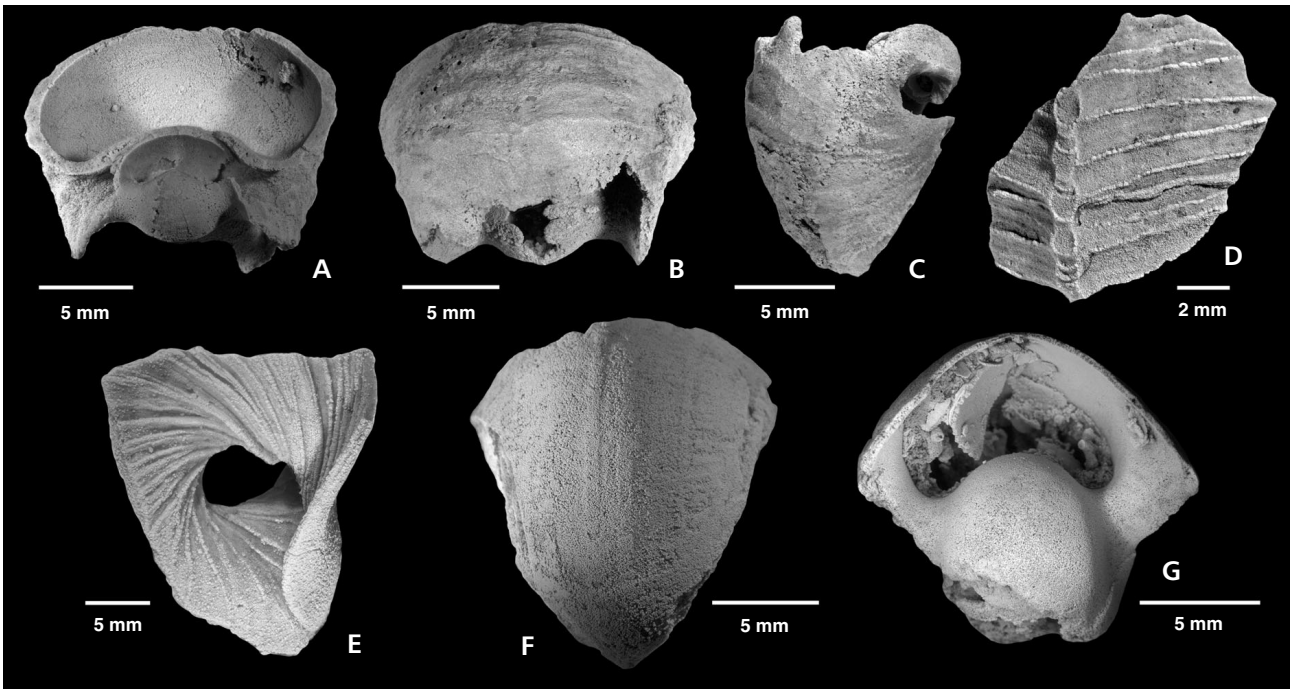

Figure 6. A–C – *Bellerophon* sp., SNSB-BSPG 2014 XI 49. • D – *Bellerophon* sp., shell fragment showing collabral lirae and selenizone bordered by undulating lirae, SNSB-BSPG 2014 XI 65. • E – *Bellerophon* sp., fragment of umbilical region, SNSB-BSPG 2014 XI 107. • F, G – *Bellerophon*? sp., SNSB-BSPG 2014 XI 60.

Remarks. – *Pharkidonotus khaonoiensis* sp. nov. resembles *Khumerspira thailandensis* sp. nov. but is more slender and lacks or has much weaker lateral angulations. *Pharkidonotus khaonoiensis* has a much more bent aperture in transverse section and the crest is much more pronounced. It also differs in these respects from *Bellerophon* (*Pharkidonotus*) *altitropis* Kulas & Batten, 1997 (Permian, USA) and moreover, that species is phaneromphalous. *Bellerophon deflectus* Chronic, 1952 from the Permian of the USA is much broader and its aperture is less bent in transverse section and has a much more pronounced callus. *Pharkidonotus khaonoiensis* sp. nov. differs from the vast majority of species assigned to *Bellerophon* in having a strongly elevated crest with steep sides hosting the selenizone. However, some species of *Bellerophon* including its Devonian type species also have a distinctly elevated crest.

Genus *Khumerspira* Murata, 1974

Type species. – *Khumerspira ishii* Murata, 1974 (*in* Ishii & Murata), Middle Permian, Cambodia.

Remarks. – The present species *Khumerspira thailandensis* sp. nov. is assigned to the genus *Khumerspira* Murata, 1974 (*in* Ishii & Murata) because it has lateral edges, a wide low, subrectangular aperture in transverse section and a sharply projecting median crest. Accordingly, *Khumerspira* has also strongly reflexed lateral lips but judging from the illustration of the type species given in Ishii & Murata (1974), it is not quite clear what this means. *Khumerspira thailandensis* sp. nov. also resembles species of the genus *Pharkidonotus* Girty, 1912. However, *Pharkidonotus* has usually rather strong collabral transverse undulations on the shell and some species also have nodules. Given the shape and gross morphology, *Khumerspira thailandensis* sp. nov. is closer to the type species of *Pharkidonotus* as shown by Knight (1941) and Girty (1915) than to that of *Bellerophon* although this species (type of *Pharkidonotus*) has much stronger transverse rugae. The subgenus *Bellerophon Sorobanobaca* Nishida, 1969 (proposed as subgenus of *Bellerophon*) from the Middle Permian of Japan is also similar but is umbilicated and has a spiral ornament.

Khumerspira and *Pharkidonotus* are so close to each other morphologically that they may represent synonyms (Mazaev 2016, written communication). *Sorobanobaca* is also quite similar and might also be synonymous to the other two genera. However, it is beyond the scope of the present contribution to present a formal synonymization. Preliminarily, we suggest treating bellerophontoids with median crest, wide subrectangular aperture and lateral shoulders as follow:

Pharkidonotus: anomphalous, with transverse rugae and also with nodes in several species.

Khumerspira: anomphalous, ornament with growth lines only.

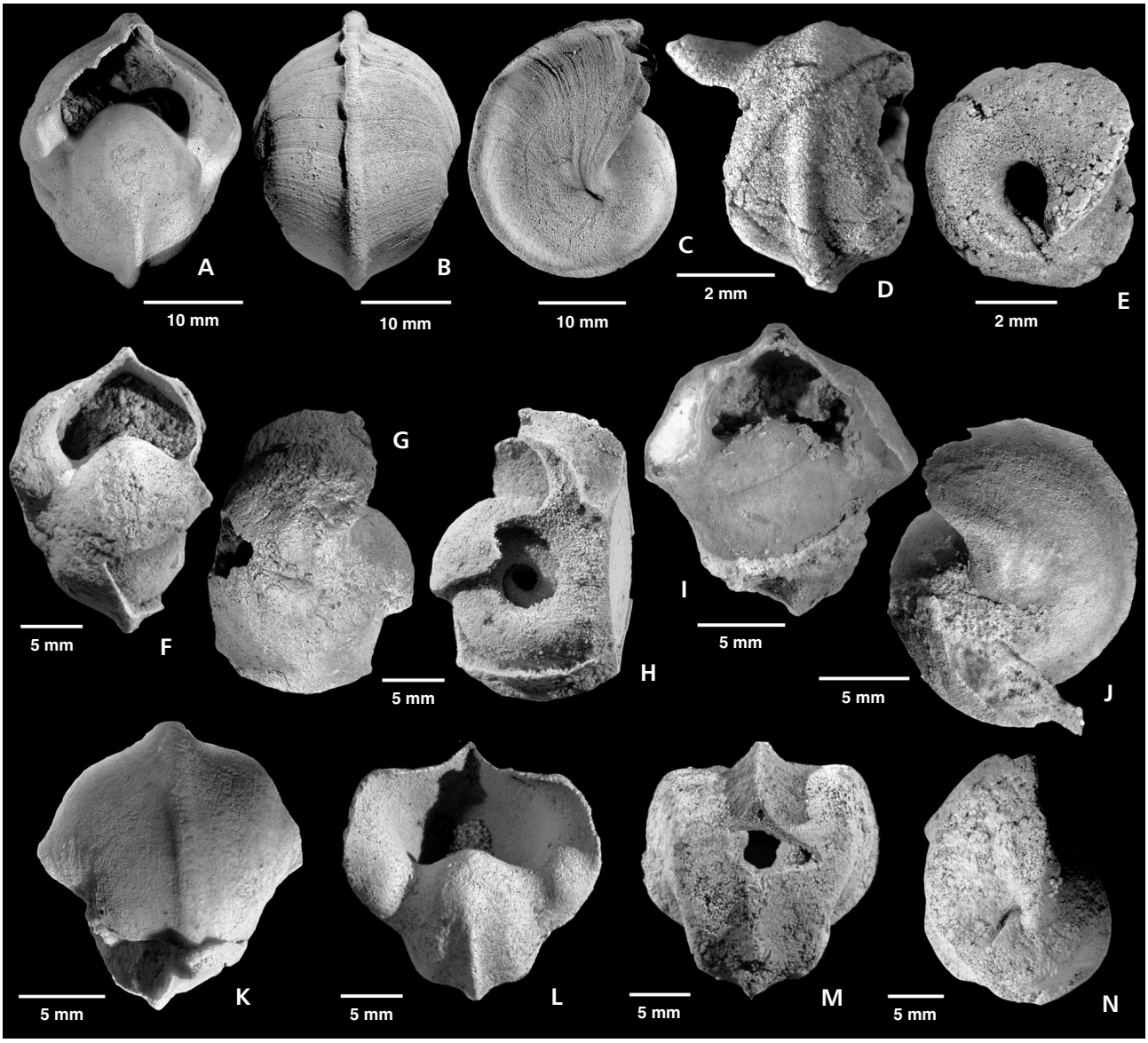

Figure 7. A–C – *Pharkidonotus khaonoiensis* sp. nov., holotype, SNSB-BSPG 2014 XI 88. • D, E – *Pharkidonotus khaonoiensis* sp. nov., paratype, SNSB-BSPG 2014 XI 4. • F–H – *Pharkidonotus khaonoiensis* sp. nov., paratype, SNSB-BSPG 2014 XI 59. • I–K – *Pharkidonotus khaonoiensis* sp. nov., paratype, SNSB-BSPG 2014 XI 61. • L–N – *Khumerspira thailandensis* sp. nov., holotype, SNSB-BSPG 2014 XI 93.

Sorobanobaca: phaneromphalous; spiral ornament present.

In that sense, *Khumerspira* might be regarded as a *Pharkidonotus* lacking strong ornament of rugae and nodes.

***Khumerspira thailandensis* sp. nov.**
Figure 7L–N

Locus typicus. – Khao Noi hill, Takhli district, Southeast of Nakhon Sawan province, *ca* 80 km south of Nakhon Sawan City, Northern Thailand, 15° 18´ 51.801˝ N, 100° 26´ 30.358˝ E (Fig. 1).

Stratum typicum. – Tak Fa Formation of the Saraburi Group, Middle Permian, Wordian.

Material. – Only the holotype, SNSB-BSPG 2014 XI 93.

Etymology. – After the country of Thailand.

Description. – Shell bellerophontiform, broad with sharp, distinctly elevated crest with selenizone and lateral rounded edges; holotype 22 mm long, 21 mm wide, 16 mm thick; shell concave between crest and lateral edges; shell slightly convex below edges; whorls approximately rectangular in transverse section; whorl surface largely smooth, only

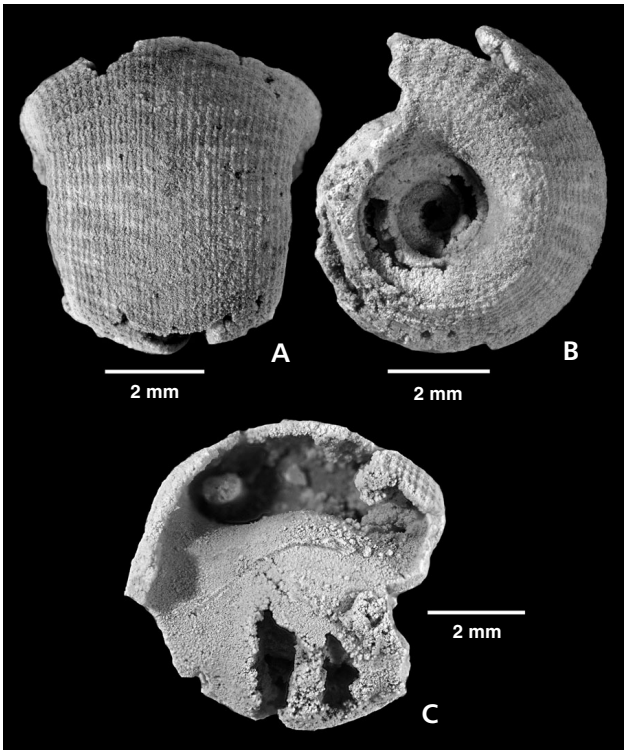

Figure 8. A–C – *Retispira lyelli* (Gemmellaro, 1890), SNSB-BSPG 2014 XI 32.

weak traces of collabral rugae on dorsal side; growth lines very faint, not well-preserved; aperture broad, anterior lip thin, V-shaped at crest; posterior lip concave due to previous whorl, with parietal inductura and two lateral pads, smooth and thick; umbilici completely covered.

Remarks. – As mentioned above, *Khumerspira thailandensis* sp. nov. resembles species of the genus *Pharkidonotus* in gross morphology but lacks strong rugae and nodes. It resembles *Bellerophon* (*Sorobanobaca*) *matsumotoi* Nishida, 1969 from the Middle Permian of Japan. However, this species and subgenus has a collabral and spiral ornament, which is lacking in the present material. Moreover, Nishida (1969) mentioned that his species is phaneromphalous. *Khumerspira thailandensis* sp. nov. is also similar to *Bellerophon khaonoiensis* sp. nov. as described above but the shoulder of this species is rounded or only slightly angulated and the anterior lip has steeper sides. *Pharkidonotus thailandensis* sp. nov. also resembles *Bellerophon deflectus* Chronic, 1952 (which may be transferred to *Khumerspira*) from the Early Permian of Arizona but the dorsal crest is less elevated in the latter and it is much larger. Yochelson (1960) reported a similar species from the Permian of Texas as "*Bellerophon* (?) species" but this shell is widely phaneromphalous. Yochelson (1960) stated that because of the crest, this species would not represent *Bellerophon* in a strict sense.

Subfamily Knightitinae Knight, 1956

Genus *Retispira* Knight, 1945

Type species. – *Retispira bellireticulata* Knight, 1945, Middle Permian, Texas.

***Retispira lyelli* (Gemmellaro, 1890)**
Figure 8A–C

1972 *Retispira lyelli* (Gemmellaro, 1890). – Batten, p. 13, figs 6, 7 (here more synonymy).

Material. – Two specimens, SNSB-BSPG 2014 XI 26, 32.

Remarks. – This rather characteristic species was originally described from the Sosio Limestone of Sicily, Italy. Batten (1972) reported it from the Permian of Perak, Malaysia and considered several taxa described from Asia and North America to represent synonyms. The larger present specimen is 6.3 mm long, 5.7 mm wide and 4.4 mm thick. It is distinctly phaneromphalous, has low whorls and an ornament of strengthened growth lines and densely spaced spiral threads.

Basal taxa that are certainly Gastropoda
Superfamily Euomphaloidea White, 1877
Family Euomphalidae White, 1877

Genus *Discotropis* Yochelson, 1956

Type species. – *Discotropis publicus* Yochelson, 1956, Permian, USA.

Remarks. – *Discotropis* was previously placed in Omphalotrochidae (Knight *et al.* 1960) but was placed in Euomphalidae by Linsley & Kier (1984) without explaining on what grounds. The present material does not contribute to solve the question which of these assignments would be the better choice.

***Discotropis*? sp.**
Figure 9A–C

Material. – One specimen, SNSB-BSPG 2014 XI 91.

Description. – Discoidal, widely phaneromphalous dextral shell with lower umbilicus somewhat deeper than upper umbilicus; diameter 2.9 mm, height 1.2 mm; strong angulation above mid-whorl and a further angulation on the upper side of whorls; whorl profile asymmetrical with slope *ca* 45° above angular periphery and much steeper below it; lower side of whorls distinctly convex; transition from whorl face

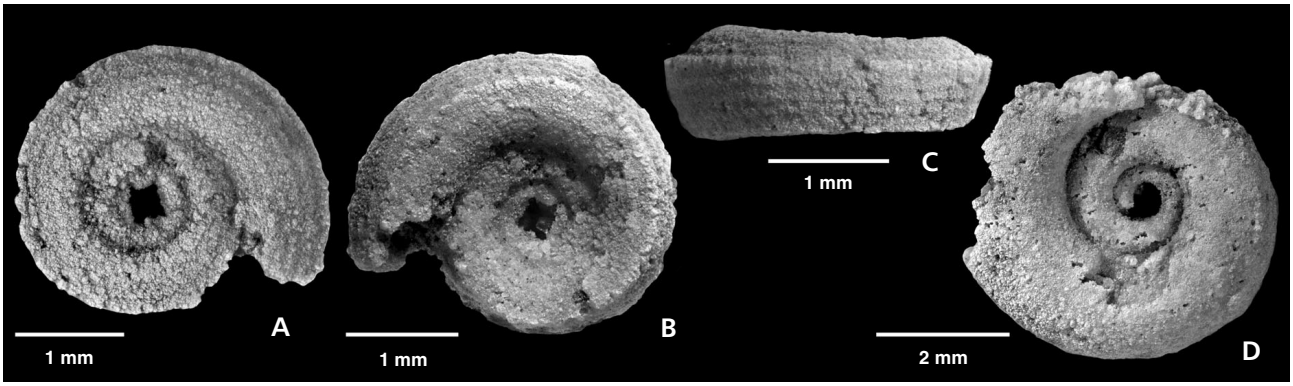

Figure 9. A–C – *Discotropis*? sp., SNSB-BSPG 2014 XI 91. • D – *Euomphalus*? sp., SNSB-BSPG 2014 XI 69.

to base distinctly angular; distinct spiral cords present on whorl face, four below periphery and at least one above; suture distinct; aperture subcircular, as wide as high.

Remarks. – The present specimen resembles *Discotropis klobukowskii* Mansuy, 1912 from the Carboniferous of Yunnan, a species also reported by Delpey (1941) from the Permian of Cambodia. However, that species has a slightly elevated spire, axial sculptural elements and an upper edge. The present species probably represents a new species that may represent the genus *Discotropis* but the single specimen to is too poorly preserved for a sufficient characterization. The generic and suprageneric assignment of this species is uncertain because tiny planispiral shells are present in various gastropod groups (*e.g*., Bandel 1988).

Genus *Euomphalus* Sowerby, 1814

Type species. – *Euomphalus pentangulatus* J. Sowerby, 1814, Carboniferous, Great Britain.

***Euomphalus*? sp.**
Figure 9D

Material. – One specimen, SNSB-BSPG 2014 XI 69.

Description. – Discoidal, widely phaneromphalous shell with both umbilici equally deepened; diameter 23 mm; whorls round, almost circular in transverse section; whorl surface smooth; suture deep.

Remarks. – This small planispiral shell may represent early whorls of an unknown euomphalid.

Unassigned to superfamily
Family Raphistomatidae Koken, 1896
Subfamily Omospirinae Wenz, 1938

Genus *Baylea* de Koninck, 1883

Type species. – *Trochus yvanii* Léveillé, 1835, Carboniferous, Belgium.

Remarks. – Knight *et al.* (1960) and Batten (1995) placed *Baylea* in Raphistomatidae Koken, 1896 but Mazaev (2015) placed it in Phymatopleuridae.

***Baylea*? *umbilicata* sp. nov.**
Figure 10

2014 *Worthenia*? sp.; Ketwetsuriya *et al.*, p. 140, pl. 1, fig. j.

Locus typicus. – Khao Noi hill, Takhli district, Southeast of Nakhon Sawan province, *ca* 80 km south of Nakhon Sawan City, Northern Thailand, 15° 18´ 51.801˝ N, 100° 26´ 30.358˝ E (Fig. 1).

Stratum typicum. – Tak Fa Formation of the Saraburi Group, Middle Permian, Wordian.

Material. – Holotype: SNSB-BSPG 2014 XI 13, paratypes: SNSB-BSPG 2014 XI 22, 23, 29, 31, 97, 102, 103, CUMZ 7002, 7003.

Etymology. – For the distinctly umbilicated base.

Description. – Shell turbinate, moderately high-spired, gradate; holotype comprises about 6 whorls, 8.2 mm high, 6.4 mm wide; largest specimen 9.8 mm high, 6.8 mm wide; whorls sharply angulated at about mid-whorl and somewhat below middle of spire whorls; whorls with distinctly inclined subsutural ramp above and vertical, concave below angulation; angulation forms crest-like periphery of whorls; transition to base angular; whorls ornamented with numerous densely spaced spiral threads; up to eight spiral

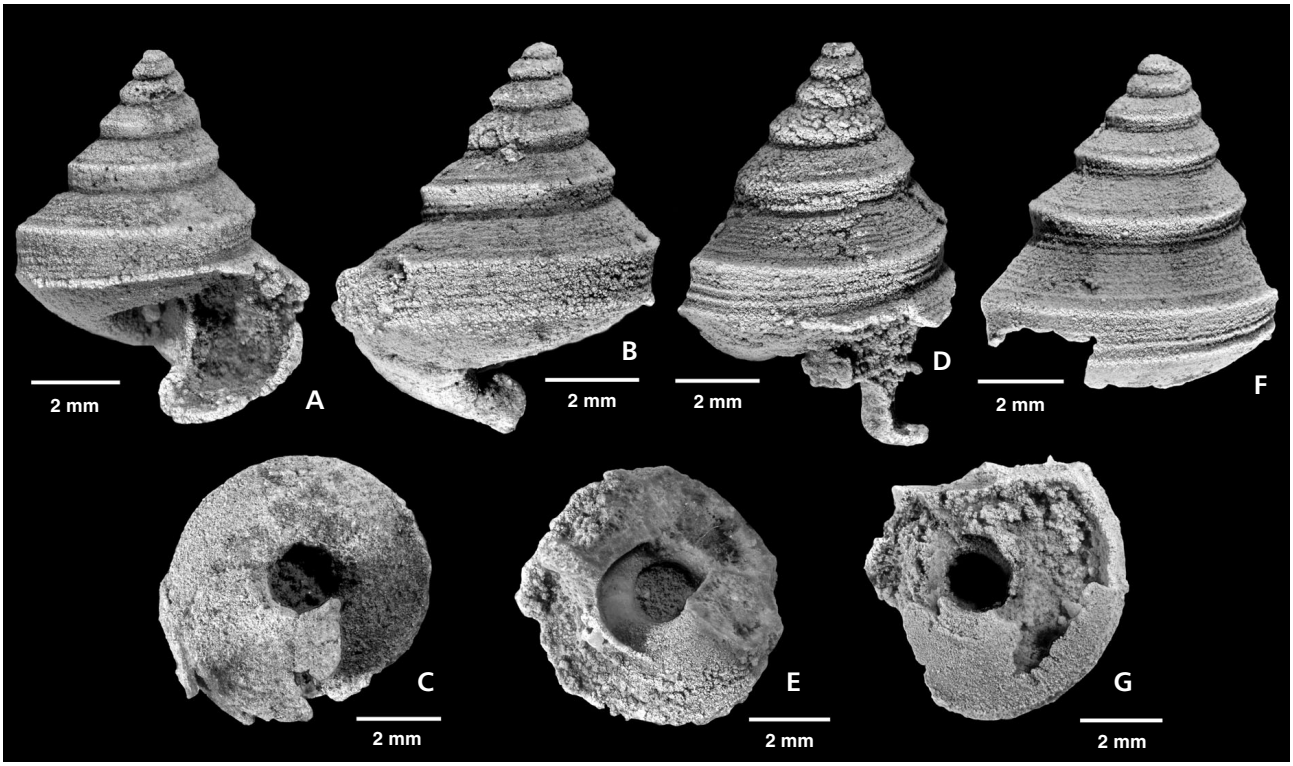

Figure 10. A–C – *Baylea*? *umbilicata* sp. nov., holotype, SNSB-BSPG 2014 XI 13. • D, E – *Baylea*? *umbilicata* sp. nov., paratype, SNSB-BSPG 2014 XI 22. • F, G – *Baylea*? *umbilicata* sp. nov., paratype, SNSB-BSPG 2014 XI 31.

threads present on ramp and at least four below angulation; growth line pattern including selenizone obscured due to preservation; selenizone probably at peripheral angulation of whorls; base flatly convex, without visible ornament, distinctly phaneromphalous with umbilicus surmounted by a rounded edge.

Remarks. – Due to the coarse silicification, growth line pattern including selenizone are obscured in the present material and thus, the generic placement is uncertain. It is likely that the selenizone is situated at the peripheral angulation of the whorls. *Baylea*? *umbilicata* sp. nov. is placed tentatively in the genus *Baylea* based on the gradate spire and the ornament of spiral lirae. The distinctly phaneromphalous base and the angular transition from whorl face to base are unusual for *Baylea* and differentiate the present species from other species of this genus. It is also possible that *Baylea*? *umbilicata* sp. nov. belongs in the genus *Platyzona* Knight, 1945. The type species of *Platyzona* is only minutely phaneromphalous and the whorls are usually not strongly angulated but rounded.

A well-preserved specimen of *Baylea yvanii*, type species of *Baylea*, from the Mississippian of Belgium was illustrated by Lindström & Peel (2005, fig. 1a). It is more high-spired than *Baylea*? *umbilicata* sp. nov., has a much shallower ramp and thus the spire is more gradate and the transition from whorl face to base is evenly rounded. Its base has only a pseudo-umbilicus. Several Middle Permian species from Russia have been assigned to *Baylea*. Most are much more high-spired than *Baylea*? *umbilicata* sp. nov. and have stronger spiral lirae which are more distant from each other and non of them has such a wide umbilicus. *Baylea perthensis* Dickins, 1963 from the Permian of Australia is much more low-spired and less distinctly gradate and has a spiral ornament on the base. *Baylea*? *umbilicata* sp. nov. resembles species of the genus *Biarmeaspira* Mazaev, 2006 for instance the Middle Permian species *B. angulata* (Nechaev, 1894) and *B. yakowlewi* (Licharev, 1967) but both have strong spiral cords on the base and they are not distinctly phaneromphalous.

Superfamily Trochonematoidea Zittel, 1895
Family Trochonematidae Zittel, 1895

Genus *Knightinella* Licharev, 1975

Type species. – *Pleurotomaria humerosa* Meek & Hayden, 1858, Carboniferous, USA.

Remarks. – *Knightinella* was proposed as a subgenus of *Amaurotoma* Knight, 1945.

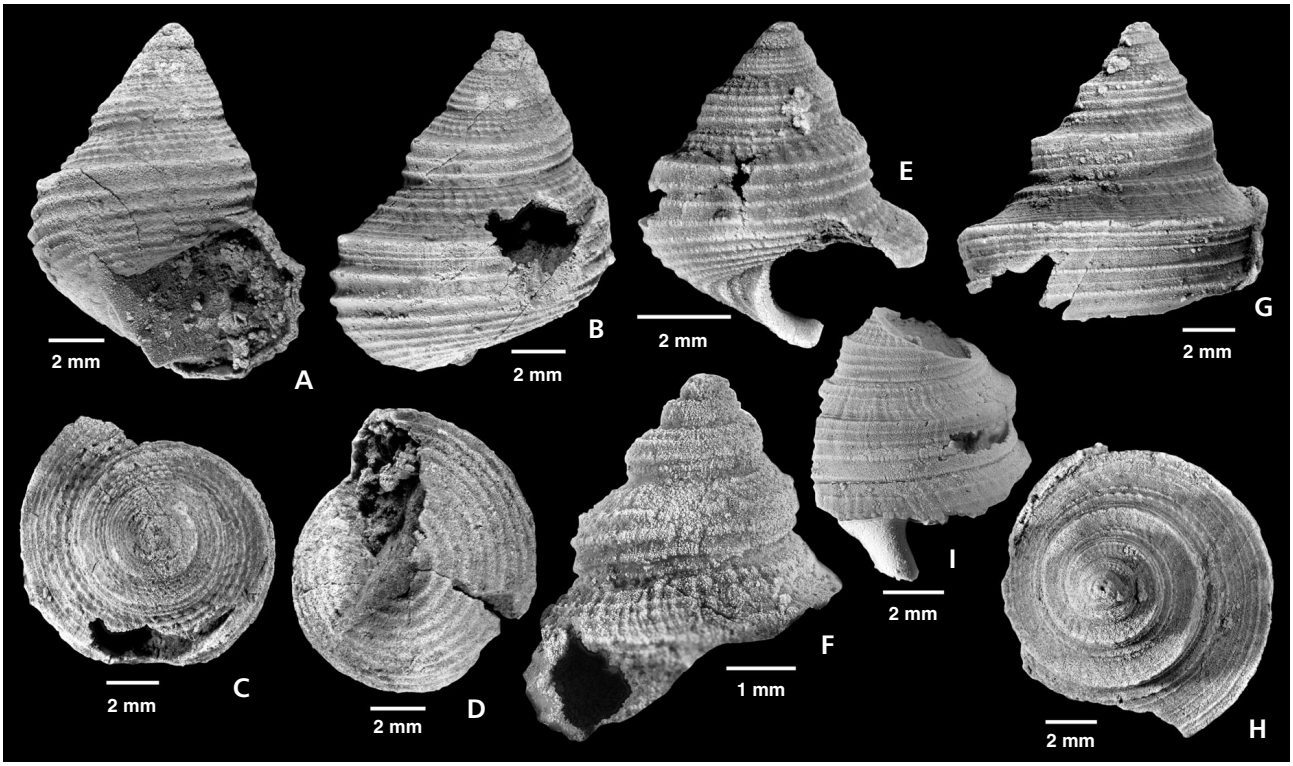

Figure 11. A–D – *Knightinella ornata* sp. nov., holotype, SNSB-BSPG 2014 XI 39. • E – *Knightinella ornata* sp. nov., paratype, CUMZ 7004. • F – *Knightinella ornata* sp. nov., paratype, SNSB-BSPG 2014 XI 9. • G, H – *Knightinella* sp., SNSB-BSPG 2014 XI 43. • I – *Knightinella* sp., SNSB-BSPG 2014 XI 110.

***Knightinella ornata* sp. nov.**
Figure 11A–F

2014 *Worthenia*? sp.; Ketwetsuriya *et al.*, p. 140, pl. 1, fig. i.

Locus typicus. – Khao Noi hill, Takhli district, Southeast of Nakhon Sawan province, *ca* 80 km south of Nakhon Sawan City, Northern Thailand, 15° 18´ 51.801˝ N, 100° 26´ 30.358˝ E (Fig. 1).

Stratum typicum. – Tak Fa Formation of the Saraburi Group, Middle Permian, Wordian.

Material. – Holotype: SNSB-BSPG 2014 XI 39; paratypes: SNSB-BSPG 2014 XI 9, CUMZ 7004.

Etymology. – Latin ornamented.

Description. – Shell acutely turbiniform, moderately high-spired; holotype (largest specimen) consisting of *ca* 5 whorls, earliest whorls missing, 13.5 mm high, 10.2 mm wide; early teleoconch whorls evenly convex; later, an angulation develops at middle of whorl face; angulation separates adapical slightly convex ramp and a subvertical, slightly convex abapical portion (outer whorl face); base evenly convex with rounded transition to whorl face, anomphalous; early teleoconch whorls with four to six spiral cords, abapical cords stronger; five to six spiral cords and weaker axial ribs or strengthened growth lines present on ramp in mature whorls; strengthened growth lines on ramp curving backward towards angulation; intersections of axial ribs and spiral cords slightly nodular; outer whorl face below angulation ornamented with three strong spiral cords and few weak spiral lirae; base with *ca* 10 distinct spiral cords; aperture circular columellar lip reflexed.

Remarks. – We assign *Knightinella ornata* sp. nov. to the genus *Knightinella* Licharev, 1975 based on the gross morphology and the dominant spiral ornamentation. Due to preservation, the growth line pattern is unclear *i.e*., whether a selenizone is present and if so, how it would look like (these features are not well documented for the type species of *Knightinella* as well). The juvenile specimen illustrated in Fig. 11F shows backward curving growth lines on the ramp and this suggests that a selenizone is present at the angulation. If the present species had a selenizone at the angulation of the whorls, it could represent the genus *Biarmeaspira* Mazaev, 2006 (see also Mazaev 2015). *Knightinella humerosa* (Meek & Hayden, 1858), the Carboniferous type species of *Knightinella* has a shallower ramp and the spiral cords are narrower (see Knight 1945, Kues & Batten 2001).

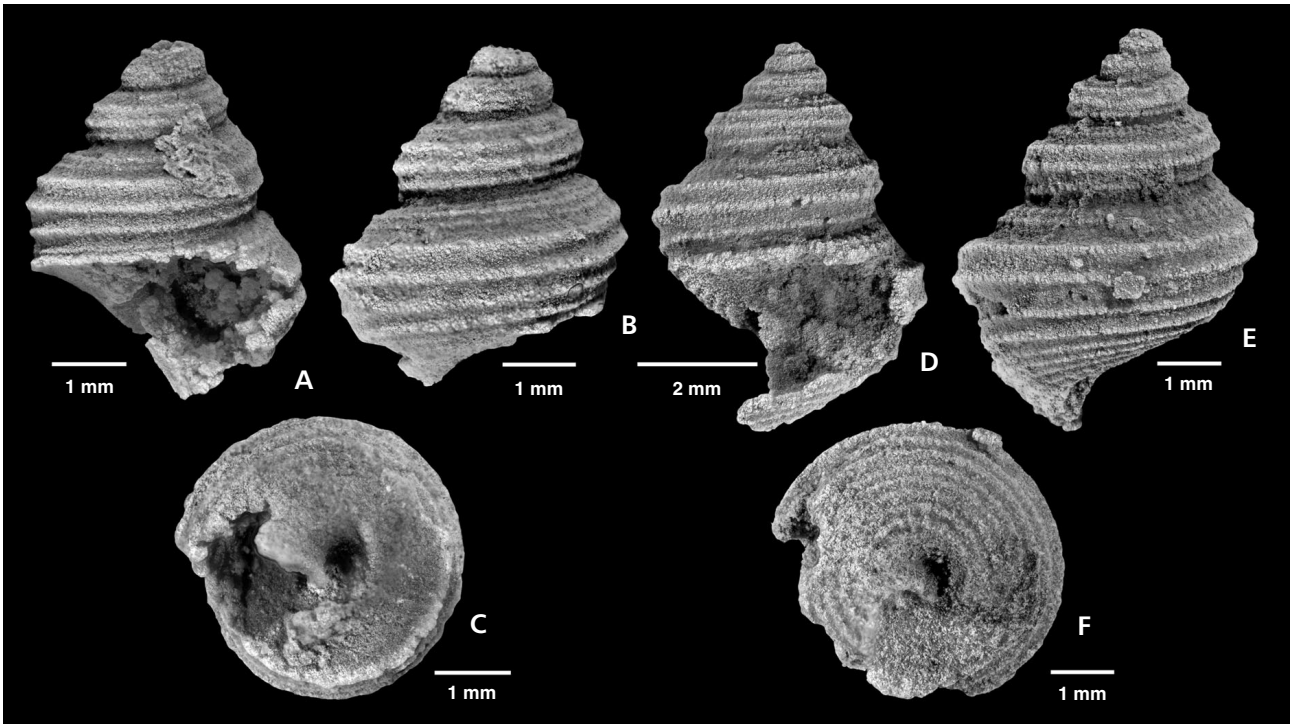

Figure 12. A–C – *Amaurotoma*? sp., SNSB-BSPG 2014 XI 16. • D–F – *Amaurotoma*? sp., SNSB-BSPG 2014 XI 64.

Amaurotoma subsinuata (Meek & Worthen, 1861), type species of the genus *Amaurotoma* Knight, 1945, lacks ramp and angulation of the whorls according to an illustration given by Knight *et al.* (1960, fig. 139/4). *Apachella* Winters, 1956 is more high-spired and the whorls are less angulated. The genus *Worthenia* yields similar species but is characterized by an elevated, nodular selenizone.

***Knightinella* sp.**
Figure 11G–I

2014 *Worthenia*? sp.; Ketwetsuriya *et al.*, p. 140, pl. 1, fig. j.

Material. – Two specimens, SNSB-BSPG 2014 XI 43, 110.

Description. – Turbinate shell with distinctly gradate spire; larger specimen *ca* 6 whorls, 11.2 mm high, 11.5 mm wide; whorls with sharp angulation above mid-whorl; ramp between adapical suture and angulation rather shallow, concave with fine spiral threads which are slightly nodular when intersecting with strengthened growth lines; adapical spiral threads somewhat stronger and more nodular than those lower on ramp; outer whorl face below angulation vertical, slightly concave; outer face with several sharp spiral threads of variable strength but generally stronger than threads on ramp; transition to base angular; base not preserved.

Remarks. – *Knightinella* sp. resembles *Knightinella ornata* sp. nov. but has a lower spire, a weaker spiral ornament and the spire is more gradate because the ramp is shallower. As in *Knightinella ornata* sp. nov., presence and nature of the selenizone are unclear due to preservation. The present shells resemble *Knightinella uralica* Licharev, 1975 from the Carboniferous of Russia but this species has fewer spiral lirae on whorl face.

Genus *Amaurotoma* Knight, 1945

Type species. – *Pleurotomaria subsinuata* Meek & Worthen, 1861, Pennsylvanian, USA.

***Amaurotoma*? sp.**
Figure 12

Material. – Three specimens, SNSB-BSPG 2014 XI 16, 64, 89.

Description. – Shell small, turbinate; largest specimen (SNSB-BSPG 2014 XI 16) comprises *ca* 3.5 whorls, 5.5 mm high, 3.6 mm wide (apex missing); whorls convex, ornamented with three strong spiral cords in abapical

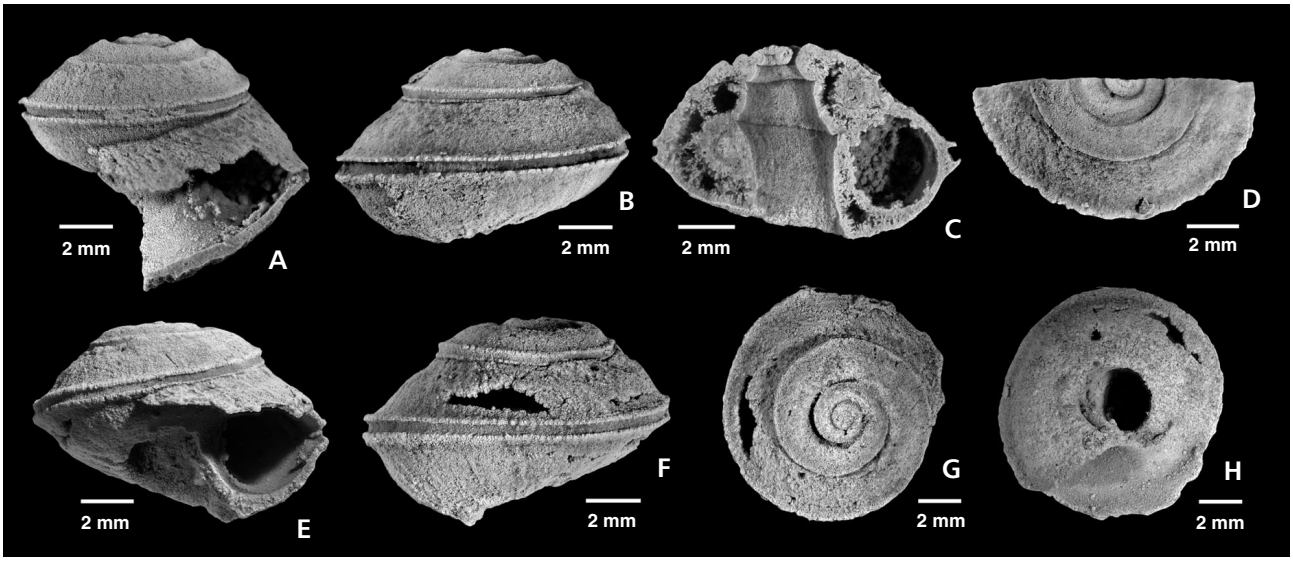

Figure 13. A–D – *Takfaia kuesi* sp. nov., paratype, SNSB-BSPG 2014 XI 10 (specimen broken in two halves). • E–H – *Takfaia kuesi* sp. nov., holotype, SNSB-BSPG 2014 XI 42.

portion of whorls; second cord forms periphery at about mid-whorl; adapical portion of whorls forms steep, straight or slightly convex ramp with three weaker spiral cords second of which somewhat more pronounced and angulating whorl face; adapical spiral cords slightly nodular; base convex, minutely phaneromphalous with up to seven distinct, narrowly spaced spiral cords; growth line pattern and aperture unknown.

Remarks. – *Amaurotoma*? sp. is distinct in this collection. Unfortunately neither growth line pattern nor aperture is known so that a further assignment is impossible. It is also possible that the species belongs to Pleurotomariida. We assign it preliminarily to *Amaurotoma* because it resembles species such as *Amaurotoma subangulatum* (Hall, 1858) from the Mississippian of the USA (see Cumings 1906, pl. 25, fig. 32). An assignment to *Baylea* or *Apachella* Chronic, 1952 is also possible. *Rhabdotocochlis* Knight, 1933 from the Late Carboniferous of the USA has a lower spire and less convex whorls.

Subclass Vetigastropoda Salvini-Plawen, 1980
Order Pleurotomariida Cox & Knight, 1960
(*in* Knight *et al.*)
Superfamily Eotomarioidea Wenz, 1938
Family Eotomariidae Wenz, 1938

Genus *Takfaia* gen. nov.

Type species. – *Takfaia kuesi* sp. nov.

Etymology. – After the Tak Fa Limestone.

Diagnosis. – Shell low-spired, trochiform with flattened spire; mature shell broadly trochiform with almost straight to slightly convex whorl face; last portion of body whorl distinctly deflected abapically; selenizone immediately above suture, forming periphery, bordered by distinctly elevated, sharp crests; selenizone concave, vertical, parallel to shell axis; adapical border of selenizone forming angulation with sloping whorl face; whorls smooth, base convex, distinctly phaneromphalous with umbilicus vertical sided, surmounted by a distinct edge.

Remarks. – *Takfaia* resembles the genus *Ambozone* Batten, 1972 (type species *Ambozone rasmusseni* Batten, 1972 from the Middle Permian of Malaysia). However, *Ambozone* is more low-spired (almost planispiral). *Euconospira* Ulrich & Scofield, 1897 is more high-spired and is either anomphalous or only minutely phaneromphalous. The Devonian genus *Oehlertia*, Perner, 1907 is similar but the selenizone is well above the suture, it is more high-spired and the shell is ornamented with fine but distinct axial lirae. The eotomariid *Bradyospira* Batten, 1964 from the Permian of Arizona is similar but has a conical, non-depressed spire and the umbilicus is much narrower.

***Takfaia kuesi* sp. nov.**
Figure 13

2014 *Discotropis*? sp.; Ketwetsuriya *et al.*, p. 142, pl. 2, fig. e.

Locus typicus. – Khao Noi hill, Takhli district, Southeast of Nakhon Sawan province, *ca* 80 km south of Nakhon Sawan City, Northern Thailand, 15° 18´ 51.801˝ N, 100° 26´ 30.358˝ E (Fig.1).

Stratum typicum. – Tak Fa Formation of the Saraburi Group, Middle Permian, Wordian.

Material. – Holotype: SNSB-BSPG 2014 XI 42; paratypes SNSB-BSPG 2014 XI 10, 17, CUMZ 7005, 7006.

Etymology. – After Barry Kues for his work on Late Palaeozoic gastropods.

Description. – Shell low-spired, trochiform with flattened apical whorls; holotype comprises *ca* 5 whorls, 7.7 mm high, 11.4 mm wide; largest specimen 9.8 mm high, 11.4 mm wide (SNSB-BSPG 2014 XI 10); earliest whorls convex, evenly rounded, very low-spired with spire only slightly elevated; after *ca* three whorls the shell becomes broadly trochiform with almost straight to slightly convex whorl face; last portion of body whorl distinctly deflected abapically; selenizone immediately above suture, forming periphery, bordered by distinctly elevated, sharp crests; selenizone vertical, parallel to shell axis; adapical border of selenizone forming angulation with sloping whorl face; abapical crest bordering selenizone emerges at suture; suture distinct; selenizone fully exposed when last portion of body whorl becomes deflected downward; whorls smooth, circular in transverse section; base convex, distinctly phaneromphalous with umbilicus opened throughout including initial whorls; umbilicus of last two whorls with vertical, slightly convex whorl sides; umbilicus surmounted by a distinct edge.

Genus *Glabrocingulum* Thomas, 1940

Type species. – *Glabrocingulum* (*Glabrocingulum*) *beggi* Thomas, 1940, Carboniferous, England.

***Glabrocingulum magnum* sp. nov.**
Figure 14

2014 *Treposira* sp.; Ketwetsuriya *et al.*, p. 139, pl. 1, figs d–g.
2014 *Glabrocingulum* sp.; Ketwetsuriya *et al.*, p. 140, pl. 1, fig. h.

Locus typicus. – Khao Noi hill, Takhli district, Southeast of Nakhon Sawan province, *ca* 80 km south of Nakhon Sawan City, Northern Thailand, 15° 18´ 51.801˝ N, 100° 26´ 30.358˝ E (Fig. 1).

Stratum typicum. – Tak Fa Formation of the Saraburi Group, Middle Permian, Wordian.

Material. – Holotype: SNSB-BSPG 2014 XI 92; paratypes: SNSB-BSPG 2014 XI 3, 12, 24, 25, 33, 44, 48, 50, CUMZ 7007, 7008.

Etymology. – Latin magnum for large.

Description. – Shell trochiform, low-spired, with slightly coeloconoid spire; body whorl height about 65% of total height; holotype (largest specimen) *ca* 40 mm high and wide; apical angle of up to 90°; whorls angulated at about mid-whorl; second angulation at transition to base; outer face between angulations vertical (parallel to shell axis), concave; whorls above adapical angulation straight to slightly concave, forming evenly sloping ramp; narrow concave selenizone on adapical angulation bordered by distinct, sharp spiral lirae; whorls embrace just below selenizone so that selenizone is in suprasutural position in spire whorls; whorls ornamented with a row of subsutural axially elongated nodes which become stronger during ontogeny; in mature specimens this nodular row forms a bulge that is adpressed to previous whorl; remainder ramp with several spiral lirae; abapical portion between carinations with several spiral cords which may be slightly nodular; growth lines prosocline on ramp and prosocyrt below adapical carination; base convex to conical, anomphalous with circumumbilical carination; base with variable number of spiral cords including one formed by carination; basal spiral cords may be nodular, especially in mature whorls; aperture oblique oval.

Remarks. – With up to 40 mm in height and width, *Glabrocingulum magnum* sp. nov. is a rather large representative of the genus *Glabrocingulum*. The strong subsutural nodes and the angulations on the base and at the transition to the base are especially characteristic for this species. There are numerous Late Palaeozoic species of *Glabrocingulum* most of which are smaller and have a finer ornament. *Glabrocingulum coronatum* Chronic, 1952 from the Permian Kaibab Formation of Arizona, USA is much smaller, has a lower spire, a much finer ornament and it lacks a carinated and ornamented base (see also Batten 1989, pl. 1, figs 1–23). *Glabrocingulum beedei* (Mark, 1912) from the Pennsylvanian of Ohio and the Pennsylvanian/Permian transition of New Mexico has a lower spire, is much smaller, subsutural nodes are not as pronounced and it has no pronounced carination at the transition to the base (see Sturgeon 1964, Kues 2004). The Permian species *Glabrocingulum sarrauti* (Mansuy, 1912) and *Glabrocingulum stankovski* Mazaev, 2006 are similar but have a lower spire, differ in details of the ornament and have no pronounced basal angulation (see Batten 1972, figs 12, 13; Mazaev 2006, fig. 1).

Order Trochida Cox & Knight, 1960 (*in* Knight *et al.*)
Superfamily Trochoidea Rafinesque, 1815
Family Anomphalidae Wenz, 1938

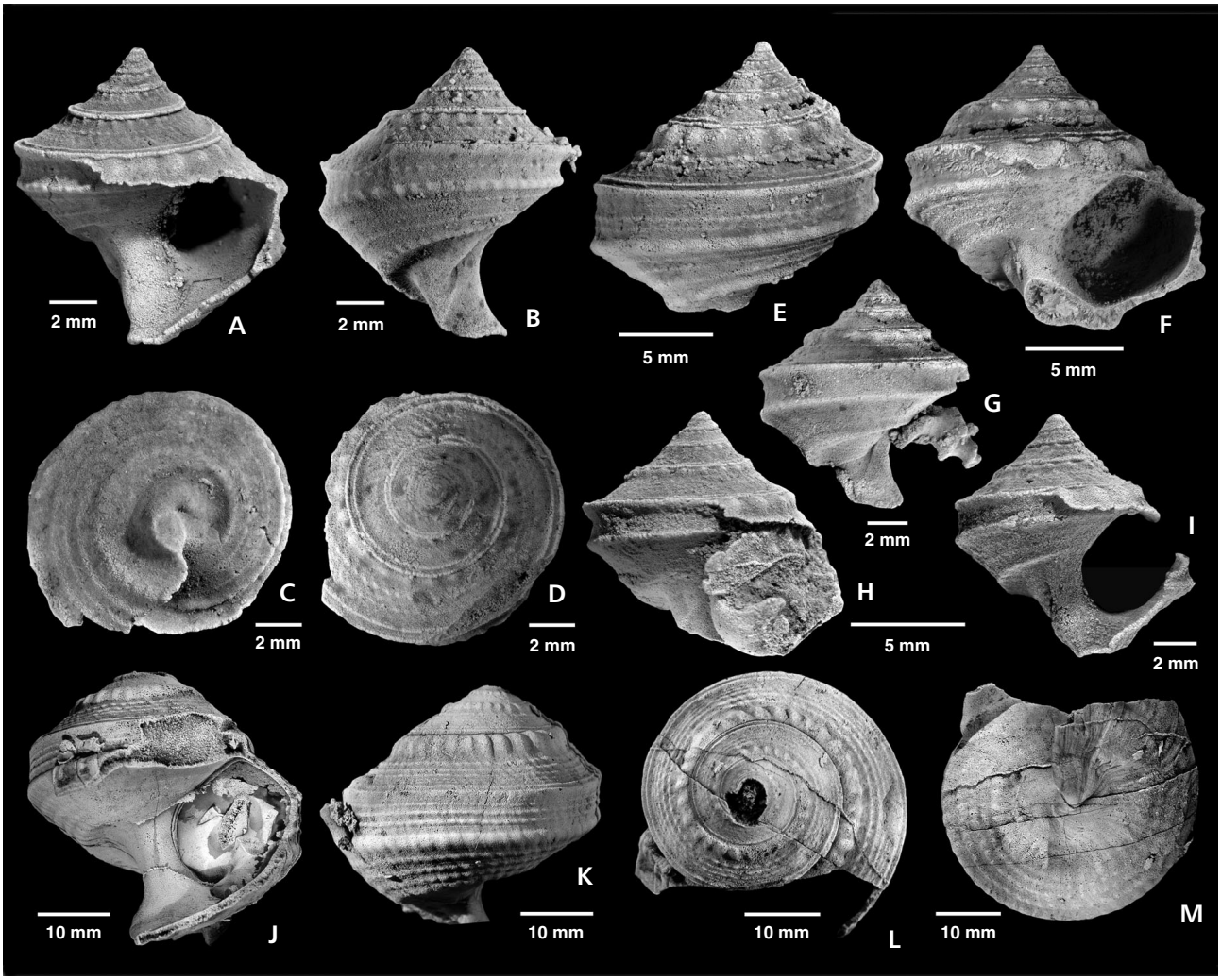

Figure 14. A–D – *Glabrocingulum magnum* sp. nov., paratype, SNSB-BSPG 2014 XI 12. • E, F – *Glabrocingulum thailandensis* sp. nov., paratype, SNSB-BSPG 2014 XI 48. • G – *Glabrocingulum thailandensis* sp. nov., paratype, SNSB-BSPG 2014 XI 50. • H – *Glabrocingulum thailandensis* sp. nov., paratype, SNSB-BSPG 2014 XI 24. • I – *Glabrocingulum thailandensis* sp. nov., paratype, SNSB-BSPG 2014 XI 25. • J–M – *Glabrocingulum thailandensis* sp. nov., holotype, SNSB-BSPG 2014 XI 92.

Genus *Anomphalus* Meek & Worthen, 1866

Type species. – *Anomphalus rotulus* Meek & Worthen, 1867, Carboniferous, USA.

***Anomphalus lateumbilicatus* sp. nov.**
Figure 15A–G

Locus typicus. – Khao Noi hill, Takhli district, Southeast of Nakhon Sawan province, *ca* 80 km south of Nakhon Sawan City, Northern Thailand, 15° 18´ 51.801˝ N, 100° 26´ 30.358˝ E (Fig. 1).

Stratum typicum. – Tak Fa Formation of the Saraburi Group, Middle Permian, Wordian.

Material. – Two specimens, holotype: SNSB-BSPG 2014 XI 115; paratype: SNSB-BSPG 2014 XI 116.

Etymology. – Latin widely umbilicated.

Description. – Shell minute, discoidal with almost flat, only slightly elevated spire; holotype comprising *ca* five whorls, diameter 2.7 mm, 1.5 mm high, whorls smooth, with distinctly convex periphery and flatly convex adapical side; whorls increasing slowly in diameter; suture distinct; base with wide umbilicus with circumumbilical rounded edge.

Remarks. – *Anomphalus lateumbilicatus* sp. nov. differs from all its congeners by its minute size, its very wide

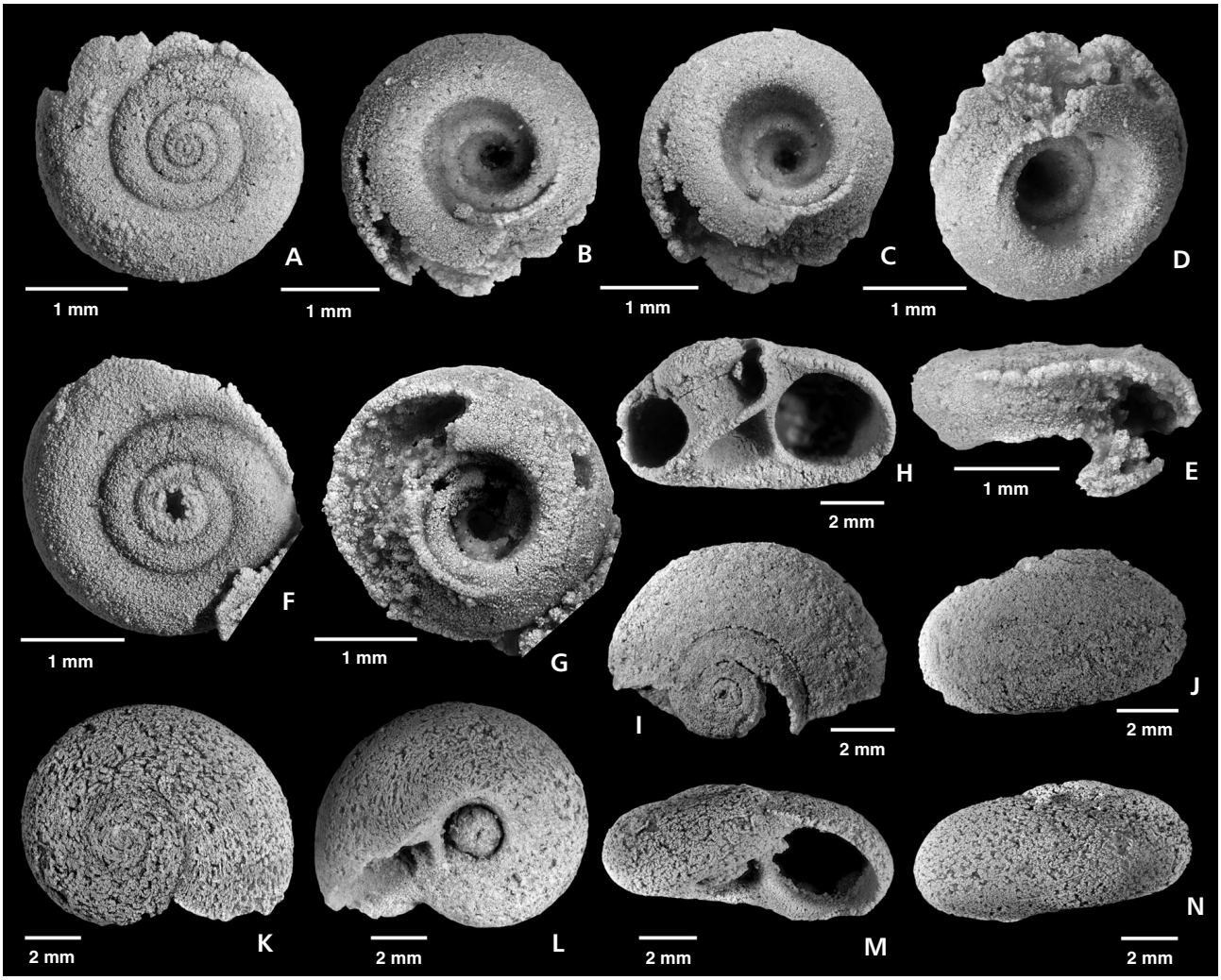

Figure 15. A–E – *Anomphalus lateumbilicatus* sp. nov., holotype, SNSB-BSPG 2014 XI 115. • F, G – *Anomphalus lateumbilicatus* sp. nov., paratype, SNSB-BSPG 2014 XI 116. • H–J – *Anomphalus* sp., SNSB-BSPG 2014 XI 20. • K–N – *Anomphalus* sp., SNSB-BSPG 2014 XI 28.

umbilicus and the slow increase in whorl diameter. The most similar species is *Anomphalus straparoliformis* Mazaev, 1997 from the Middle Carboniferous of the Russian Platform. However, this species is much larger (at a comparable number of whorls), the whorls do increase faster in diameter and the umbilicus is smaller in relation to the total width of the shell.

***Anomphalus* sp.**
Figure 15H–N

2014 *Anomphalus* cf. *japonicus* Nützel, 2012. – Ketwetsuriya *et al.*, p. 140, pl. 2, figs a, b.

Material. – Three specimens, SNSB-BSPG 2014 XI 6, 20, 28.

Description. – Shell small, low-spired, rotelliform; largest specimen with diameter of 5.2 mm, height 4.3 mm; whorls smooth, with convex periphery and flattened ab- and adapical sides, round, circular in transverse section; base distinctly umbilicated with circumumbilical edge; suture shallow, indistinct.

Remarks. – The present specimens are typical representatives of *Anomphalus* but the preservation is too poor to establish species identity. They resemble *Anomphalus japonicus* Nützel, 2012 (*in* Nützel & Nakazawa) from the Middle Permian of Japan. However, *A. japonicus* has a much deeper suture and the adapical portion of the whorl is much more convex. Moreover, this species is much smaller. The Late Carboniferous *Anomphalus rotulus* Meek & Worthen, 1867 as illustrated by Knight (1933) is similar but has an umbilical plug. *Anomphalus umbilicatus* Knight, 1933 from the Pennsylvanian of the USA is also very similar. *Anomphalus* sp. from the Permian of Perak, Malaysia is more high-spired and its umbilicus is

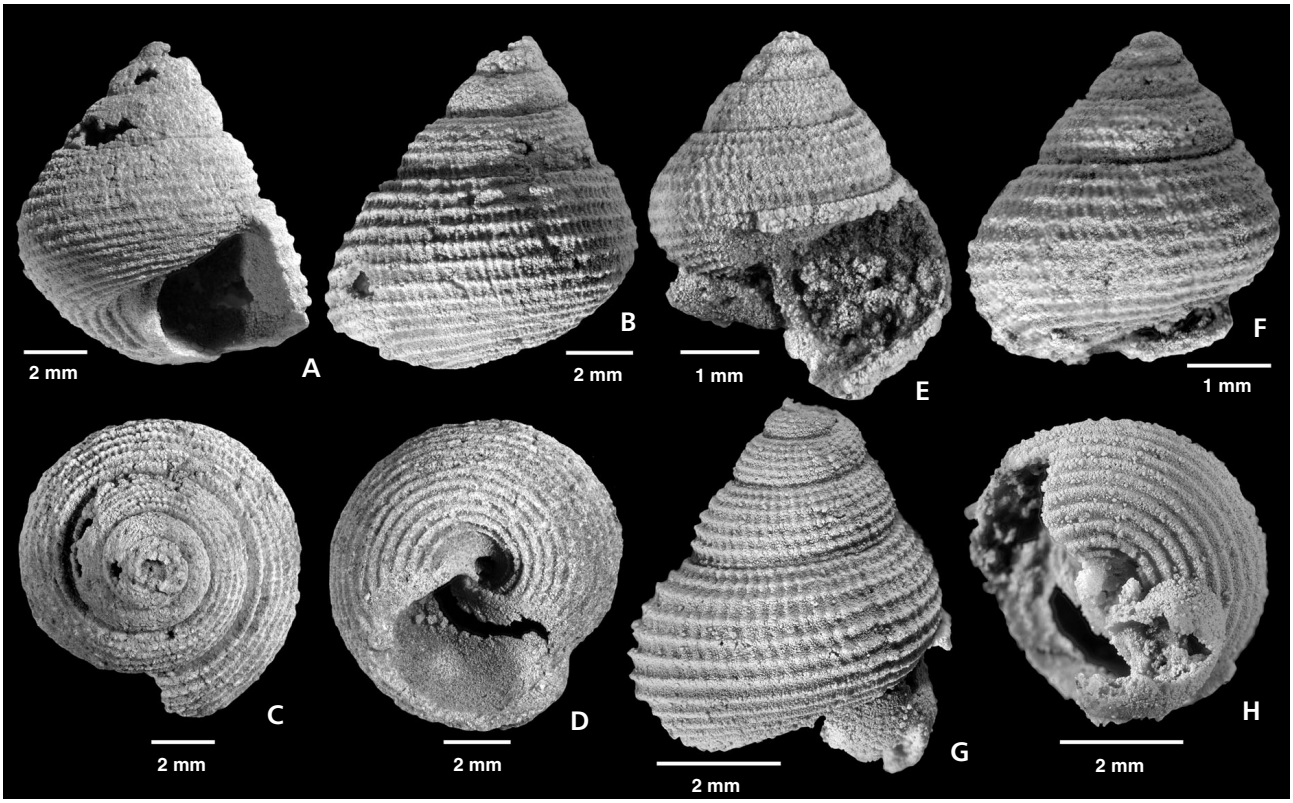

Figure 16. A–D – *Yunnania pulchra* sp. nov., holotype, SNSB-BSPG 2014 XI 34. • E, F – *Yunnania pulchra* sp. nov., paratype, SNSB-BSPG 2014 XI 21. • G, H – *Yunnania pulchra* sp. nov., paratype, SNSB-BSPG 2014 XI 108.

filled with a plug (Batten 1979, figs 10, 11). *Anomphalus*? *sundaicus* Wanner, 1942 (according to Yochelson 1956 not a representative of *Anomphalus*) from the Permian of Timor has a flatter spire and more rapidly increasing whorls. The *Anomphalus* species that were illustrated by Yochelson (1956) from the Permian of the USA have a flatter spire.

Family Araeonematidae Nützel, 2012
(*in* Nützel & Nakazawa)

Genus *Yunnania* Mansuy, 1912

Type species. – *Yunnania termieri* Mansuy, 1912, Late Carboniferous, China.

***Yunnania pulchra* sp. nov.**
Figure 16

2014 *Tapinotomaria*? sp.; Ketwetsuriya *et al.,* p. 140, pl. 1, fig. k.

Locus typicus. – Khao Noi hill, Takhli district, Southeast of Nakhon Sawan province, *ca* 80 km south of Nakhon Sawan City, Northern Thailand, 15° 18´ 51.801˝ N, 100° 26´ 30.358˝ E (Fig. 1).

Stratum typicum. – Tak Fa Formation of the Saraburi Group, Middle Permian, Wordian.

Material. – Holotype: SNSB-BSPG 2014 XI 34; paratypes: SNSB-BSPG 2014 XI 21, 108, CUMZ 7009, 7010.

Etymology. – Latin beautiful.

Description. – Shell turbiniform; holotype comprising *ca* 4 whorls (apex missing), 9.3 mm high, 9.7 mm wide; suture impressed; whorls slightly convex and slightly shouldered; whorls embrace at periphery so that periphery is at suture; base convex with evenly rounded transition to whorl face; whorls ornamented with evenly spaced distinct spiral cords; distance between cords about twice as wide as cords; cords have approximately same strength; whorls also ornamented with numerous collabral, densely spaced, slightly prosocline axial threads; intersections of spiral cords and axial threads slightly nodular; base shallowly convex, anomphalous, ornamented with up to 10 strong spiral cords and a smooth circumumbilical area; aperture approximately as high as wide; outer and inner

lip convex, parietal lip concave; aperture acute adapically.

Remarks. – *Yunnania meridionalis* Mansuy, 1914b from the Permian Productus Limestone of Cambodia is similar to *Yunnania pulchra* sp. nov. but *Y. meridionalis* has more convex whorls and the axial ribs are not sharp and thread-like but broad and low – Mansuy (1914b) described them as "ondulations transverses", *i.e*., transverse undulations. Moreover, the spiral cords are stronger in *Yunnania meridionalis.* The illustration of *Yunnania meridionalis* given by Delpey (1941) resembles the present specimens in shape but especially the nature of the axial ornament cannot be inferred from this illustration. The illustration of the specimen from the Permian of Malaysia determined as *Yunnania meridionalis* by Batten (1972) seems to be much more high-spired than *Y. meridionalis* and *Yunnania pulchra* sp. nov. so that it is not clear whether this specimen really represents *Y. meridionalis*. Other gastropod species assigned to *Yunnania* generally lack axial ornament.

Family Trochidae Rafinesque, 1815

Genus *Anticonulus* Cossmann, 1918

Type species. – *Trochus mariae* d'Orbigny, 1853, Early Jurassic, France.

***Anticonulus*? sp.**
Figure 17A, B

2014 Pleurotomarioid indet. – Ketwetsuriya *et al.*, p. 140, pl. 1, fig. l.

Material. – One specimen, SNSB-BSPG 2014 XI 8.

Description. – Shell acutely conical, small, comprising *ca* 9 whorls (apex missing), 5.8 mm high, 3.8 mm wide; flanks straight; whorl face straight with periphery at transition to base; suture shallow; transition to base markedly angular with a protruding edge; base flat, slightly conical, smooths.

Remarks. – This small conical shell resembles the Mesozoic (Triassic/Jurassic) genus *Anticonulus*.

Genus *Coeloconulus* Nützel, 2012 (*in* Nützel & Nakazawa)

Type species. – *Coeloconulus panae* Nützel, 2012 (*in* Nützel & Nakazawa), Middle Permian, Japan.

Remarks. – When Nützel (*in* Nützel & Nakazawa 2012) introduced *Coeloconulus*, he did not differentiate it from the similar Triassic genus *Callotrochus* Kutassy *in* Wenz, 1938 (see Szabó 2011). In contrast to *Coeloconulus*, *Callotrochus* has a distinctly conical base and thus, the shell as a whole is biconical. Moreover, *Callotrochus* is much larger.

***Coeloconulus panae* Nützel, 2012 (*in* Nützel & Nakazawa)**
Figure 17D–F

Material. – One specimen, SNSB-BSPG 2014 XI 109.

Remarks. – This tiny conical, coeloconoid and phaneromphalous shell is obviously identical with *Coeloconulus panae* as reported from the Middle Permian Akasaka Limestone from Japan (Nützel & Nakazawa 2012) although it is much larger and has a more convex base.

Genus *Eocalliostoma* Haas, 1953

Type species. – *Calliostoma interruptum* Cox, 1949, Late Triassic, Peru.

***Eocalliostoma* sp.**
Figure 17C

Material. – One specimen, SNSB-BSPG 2014 XI 81.

Remarks. – A single acutely trochiform shell (*ca* 4.5 whorls, 2.7 mm high, 1.8 wide) with straight and slightly prosocline axial ribs that do not continue onto the base represents a distinct species in this collection. It resembles the Triassic genus *Eocalliostoma* Haas, 1953 (see also Knight *et al.* 1960, Nützel & Erwin 2004). The present specimen also resembles juvenile specimens of the caenogastropod *Palaeostylus lateapicatus* Nützel, 2012 (*in* Nützel & Nakazawa 2012, p. 149, fig. 23o) from the Permian of the Akasaka Limestone, Japan but the latter species has lower whorls and orthocline axial ribs.

Family Microdomatidae Wenz, 1938

Genus *Microdoma* Meek & Worthen, 1866

Type species. – *Microdoma conicum* Meek & Worthen, 1866; USA, Carboniferous.

***Microdoma carinata* sp. nov.**
Figure 18

2014 *Babylonites*? sp.; Ketwetsuriya *et al.*, p. 142, pl. 2, figs f–h.

2014 *Euconodoma* sp.; Ketwetsuriya *et al.*, p. 142, pl. 2, fig. i.

Locus typicus. – Khao Noi hill, Takhli district, Southeast of Nakhon Sawan province, *ca* 80 km south of Nakhon Sawan City, Northern Thailand, 15° 18´ 51.801˝ N, 100° 26´ 30.358˝ E (Fig. 1).

Stratum typicum. – Tak Fa Formation of the Saraburi Group, Middle Permian, Wordian.

Material. – Holotype SNSB-BSPG 2014 XI 47, paratypes 2014 XI 11, 18, 19, 35, 36, 62, CUMZ 7011, 7012.

Etymology. – For the angular transition from whorl face to base.

Description. – Shell high-spired trochiform, conical with an apical angle of 50–60°; holotype consisting of about six whorls, 10.6 mm high, 7 mm wide; largest specimen (SNSB-BSPG 2014 XI 62) comprising about 5 whorls (apex missing), 12.0 mm high, 8.3 mm wide; sutures distinct; flanks straight; whorl face straight to very slightly convex with narrow adapical shoulder in some specimens; whorls largely smooth except of weak reticulate ornament of collabral axial ribs and spiral cords with nodular intersection on early teleoconch whorls; growth lines straight, prosocline; pronounced carina with spiral cord present low on the whorls, emerging from abapical suture, fully exposed on last whorl forming the periphery and angular transition to base of whorls; last part of last whorl somewhat deflected so that carina becomes fully exposed; base convex with pseudo-umbilicus formed by twisted inner lip of aperture; aperture subcircular, somewhat higher than wide; columellar lip slightly twisted forming a fold.

Remarks. – *Microdoma carinata* sp. nov. resembles the Pennsylvanian type species of *Microdoma*, *Microdoma conicum* Meek & Worthen, 1866. However, *Microdoma conicum* has rather strong nodes as teleoconch ornament and lacks a twisted inner lip. Some of the Carboniferous Russian species assigned to *Microdoma* by Mazaev (1997) resemble *Microdoma carinata* sp. nov. but these species have much stronger nodes or ribs at the suture. *Anematina permiana* (Yakowlew, 1899) as reported by Mazaev (1997) from the Late Carboniferous of the Russian Platform resembles *Microdoma carinata* sp. nov. but lacks the strong basal carination. *Euconodoma gavinae* Kues, 1990, type species of the genus *Euconodoma* Kues, 1990, from the Pennsylvanian of New Mexico is similar but *Euconodoma* has strong nodes at the basal angulation and lacks the twisted inner lip of the aperture. *Euconodoma* was considered to represent a synonym of *Microdoma* by Batten (1995). However, it seems possible that *Euconodoma* represents a distinct genus.

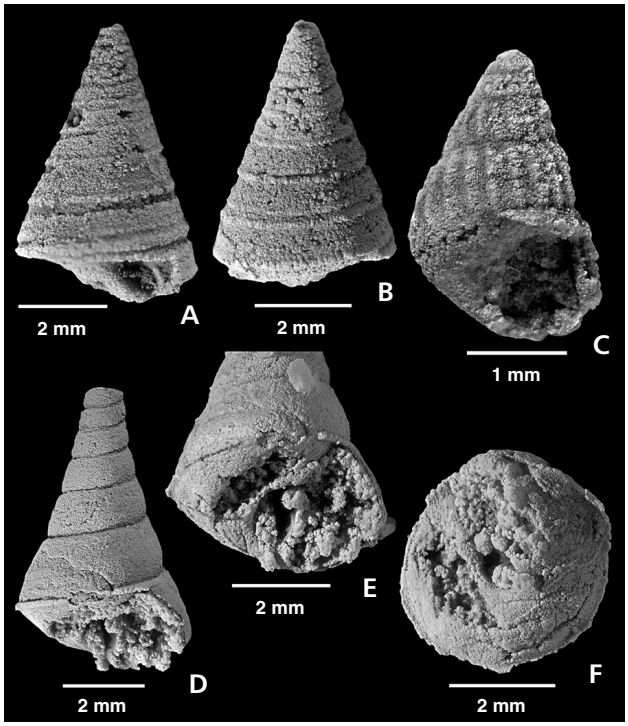

Figure 17. A, B – *Anticonulus*? sp., SNSB-BSPG 2014 XI 8. • C – *Eocalliostoma* sp., SNSB-BSPG 2014 XI 81. • D–F – *Coeloconulus panae* Nützel, 2012, SNSB-BSPG 2014 XI 109.

Subclass Neritimorpha Koken, 1896
Order Cycloneritimorpha Frýda, 1998
Superfamily Naticopsoidea Waagen, 1880
Family Naticopsidae Waagen, 1880

Genus *Naticopsis* McCoy, 1844

Type species. – *Natica ampliata* Phillips, 1836, Carboniferous, Ireland.

***Naticopsis* spp.**
Figure 19A–I

2014 *Naticopsis* sp.; Ketwetsuriya *et al.*, p. 144, pl. 2, fig. k.

Material. – Six specimens, SNSB-BSPG 2014 XI 57, 66, 68, 72, 79 95.

Remarks. – Several naticiform, low spired, smooth shells, all smaller 10 mm are present in this collection representing probably two to three species of the wide-spread and late Palaeozoic genus *Naticopsis*. The preservation of the

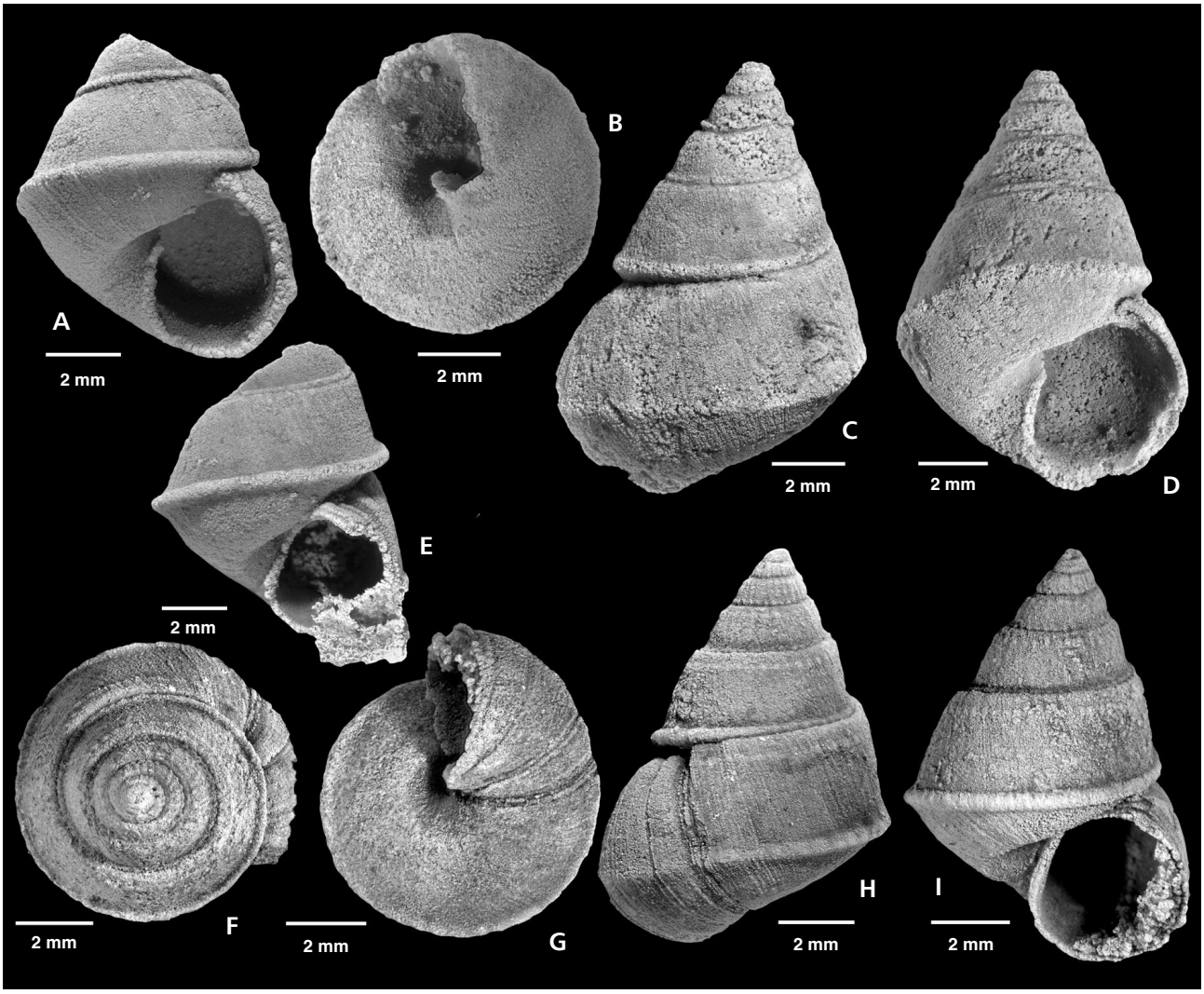

Figure 18. *Microdoma carinata* sp. nov. • A, B – paratype, SNSB-BSPG 2014 XI 19. • C, D – paratype, SNSB-BSPG 2014 XI 62. • E – paratype, SNSB-BSPG 2014 XI 11. • G–I – holotype, SNSB-BSPG 2014 XI 47.

specimens (especially the apertures) is not sufficient for identification.

Family Trachyspiridae Nützel, Frýda, Yancey & Anderson, 2007

Genus *Trachydomia* Meek & Worthen, 1866

Type species. – *Naticopsis nodosa* Meek & Worthen, 1861, Carboniferous, USA.

***Trachydomia takhliensis* sp. nov.**
Figure 19J–M

2014 *Trachydomia* sp.; Ketwetsuriya *et al.*, p. 144, pl. 2, fig. j.

Locus typicus. – Khao Noi hill, Takhli district, Southeast of Nakhon Sawan province, *ca* 80 km south of Nakhon Sawan City, Northern Thailand, 15° 18´ 51.801˝ N, 100° 26´ 30.358˝ E (Fig. 1).

Stratum typicum. – Tak Fa Formation of the Saraburi Group, Middle Permian, Wordian.

Material. – Holotype: SNSB-BSPG 2014 XI 41; paratypes SNSB-BSPG 2014 XI 37, CUMZ 7013, 7014.

Etymology. – After the district of Takhli where the species occurs.

Description. – Shell naticiform to turbiniform; holotype 11.7 mm high, 9.8 mm wide; largest specimen (SNSB-BSPG 2014 XI 87) 30 mm high (apex missing),

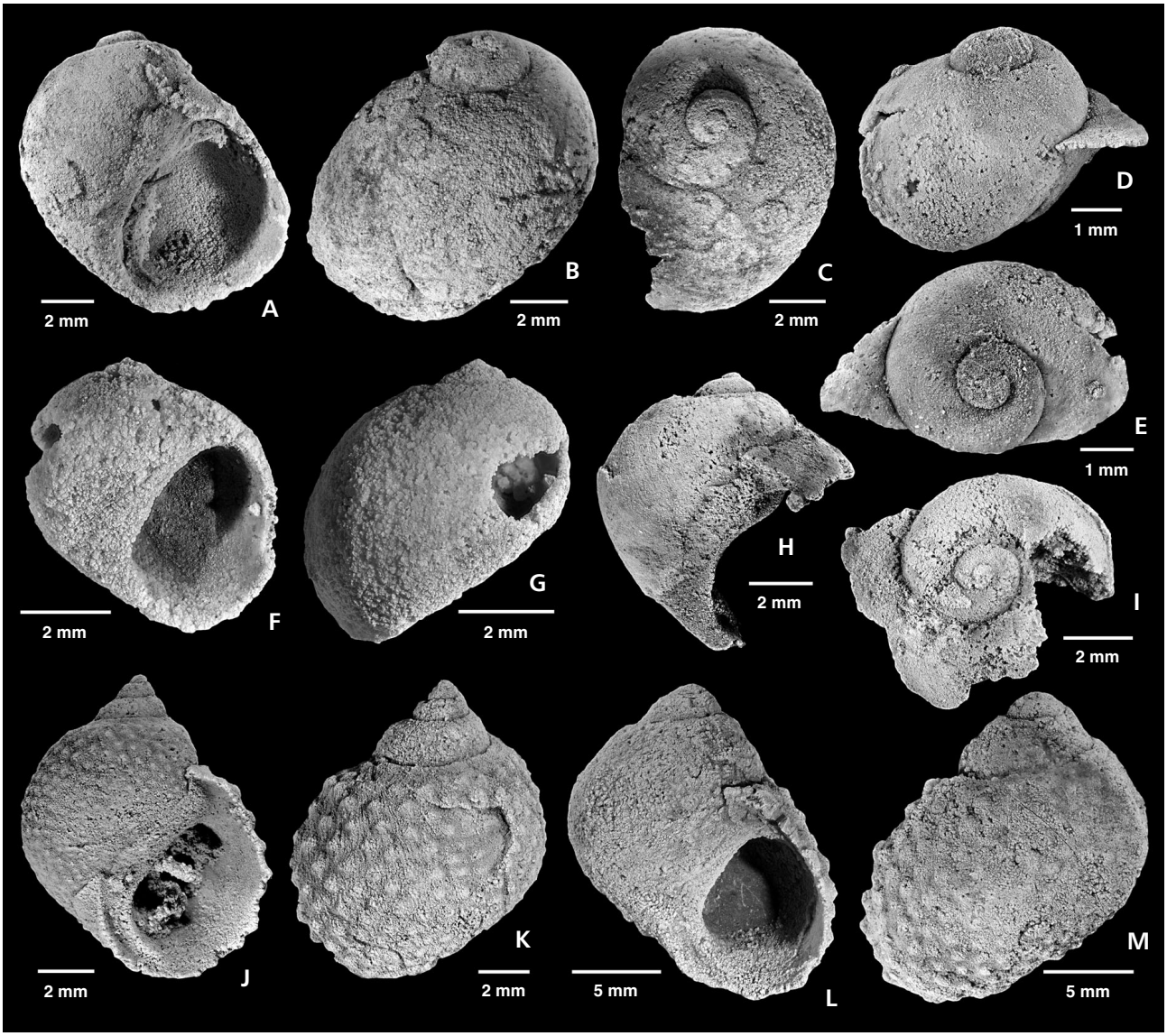

Figure 19. A–C – *Naticopsis* sp., SNSB-BSPG 2014 XI 95. • D, E – *Naticopsis* sp., SNSB-BSPG 2014 XI 72. • F, G – *Naticopsis* sp., SNSB-BSPG 2014 XI 57. • H, I – *Naticopsis* sp., SNSB-BSPG 2014 XI 66. • J, K – *Trachydomia takhliensis* sp. nov., holotype, SNSB-BSPG 2014 XI 41. • L, M – *Trachydomia takhliensis* sp. nov., paratype, SNSB-BSPG 2014 XI 37.

31 mm wide; spire acute distinctly elevated; body whorl much higher than spire with height about 85% of total height; whorls round, convex with a narrow subsutural ramp; whorls embracing at periphery; whorls ornamented with distinct nodes which are strongest on the body whorl; suture distinct; base round, convex with evenly rounded transition to base; growth lines prosocline; aperture D-shape with thickened outer lip and parietal inductura; columellar lip straight, oblique to shell axis, widened with a crescent-shaped furrow; outer lip evenly convex; base anomphalous, convex.

Remarks. – *Trachydomia takhliensis* sp. nov. is a typical representative of the genus *Trachydomia*. *Trachydomia dussaulti* Mansuy, 1913 from the Permian Productus Limestone of Laos is similar in shape but has finer and denser nodes. *Trachydomia dussaulti* has also been reported from the Permian of Perak, Malaysia by Batten (1979) and the specimen he illustrated has much finer nodes which are arranged in prosocline lines. Moreover, its ramp is less pronounced. *Trachydomia gobbeti* Batten, 1979 from the Permian of Perak, Malaysia has nodes which are strictly arranged in spiral lines and the adapical nodes are much stronger than the abapical ones. *Trachydomia imbricata* Batten, 1979 and *T. gemmulata* Batten, 1979, both from the Permian of Perak, Malaysia differ strongly from *Trachydomia takhliensis* sp. nov. in shape and ornament. *Trachydomia* cf. *nodosa* (Meek & Worthen, 1866) from the Middle

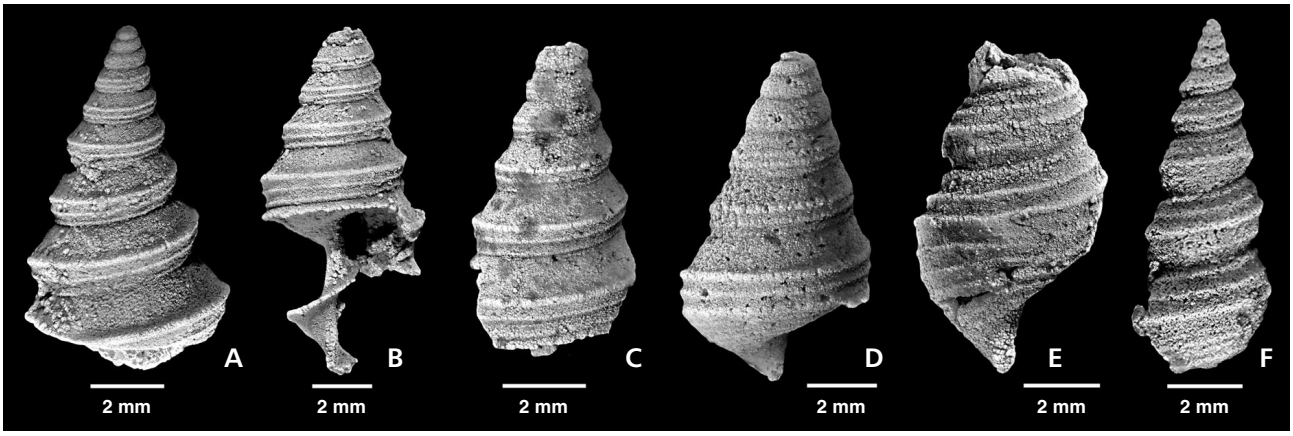

Figure 20. A – *Goniasma tricarinata* sp. nov., holotype, SNSB-BSPG 2014 XI 45. • B – *Goniasma tricarinata* sp. nov., paratype, CUMZ 7015. • C – *Goniasma tricarinata* sp. nov., paratype, CUMZ 7016. • D – *Goniasma tricarinata* sp. nov., paratype, SNSB-BSPG 2014 XI 5. • E – *Stegocoelia* sp. 1, SNSB-BSPG 2014 XI 80. • F – *Stegocoelia* sp. 1, SNSB-BSPG 2014 XI 30.

Permian of Japan as reported by Nützel & Nakazawa (2012) has nodes which are strictly arranged in spiral lines. *Trachydomia nodosa*, type species of the genus *Trachydomia*, is broader and has fewer but much coarser nodes. *Trachydomia minuta* Pan & Erwin, 2002 from the Late Permian of China is much more high-spired. *Trachydomia deprati* Mansuy, 1914b from the Permian Productus Limestone of Cambodia is broader and has less convex whorls.

Subclass Caenogastropoda Cox, 1960
Superfamily Orthonematoidea Nützel & Bandel, 2000
Family Goniasmatidae Nützel & Bandel, 2000
Subfamily Goniasmatinae Nützel & Bandel, 2000

Genus *Goniasma* Tomlin, 1930

Type species. – *Murchisonia lasallensis* Worthen, 1890, Pennsylvanian, USA.

***Goniasma tricarinata* sp. nov.**
Figure 20A–D

Locus typicus. – Khao Noi hill, Takhli district, Southeast of Nakhon Sawan province, *ca* 80 km south of Nakhon Sawan City, Northern Thailand, 15° 18´ 51.801˝ N, 100° 26´ 30.358˝ E (Fig. 1).

Stratum typicum. – Tak Fa Formation of the Saraburi Group, Middle Permian, Wordian.

Etymology. – Latin, with three carinae (spiral cords).

Material. – Holotype: SNSB-BSPG 2014 XI 45; paratypes: SNSB-BSPG 2014 XI 5, CUMZ 7015, 7016.

Description. – Shell high-spired; holotype comprises about 9 whorls, 9.5 mm high, 5.6 mm wide; suture distinct; whorls angulated at about mid-whorl with a broad, steep subsutural ramp; whorl face vertical, parallel to shell axis below angulation; abapical portion of whorls with three equally spaced prominent spiral cords; strongest spiral cord located at mid-whorl at angulation forming periphery; ramp largely smooth, straight with very weak spiral cord near the suture; base slightly rounded.

Remarks. – The present specimens resemble the Late Carboniferous type species of *Goniasma*, *Goniasma lasallensis* Worthen, 1890 (see also Mazaev 2011, p. 1564, pl. 1, figs 9–13) but in that species, the angulation is lower on the whorls and it lacks the three strong spiral cords low on the whorls. *Goniasma fortecarinata* Nützel, 2012 (*in* Nützel & Nakazawa) from the Middle Permian Akasaka Limestone, Japan is similar but the upper two spiral cords are much stronger than the abapical one.

Genus *Stegocoelia* Donald, 1889

Type species. – *Murchisonia* (*Stegocoelia*) *compacta* Donald, 1889, Early Carboniferous, Scotland.

Remarks. – The subgenus *Hypergonia* Donald, 1892 has been considered to represent a synonym of *Stegocoelia* by Mazaev (2001, 2011).

***Stegocoelia* sp. 1**
Figure 20E, F

Material. – Two specimens, SNSB-BSPG 2014 XI 30, 80.

Remarks. – These small, high-spired slender murchisoniform gastropods have a prominent ornament of four spiral cords on whorl face. The whorls are distinctly convex and somewhat angulated. They resemble several Late Palaeozoic species, for instance some species from the Carboniferous of Russia as described by Mazaev (2001). *Murchisonia dussaulti* Mansuy, 1914b from the Productus Limestone of Cambodia could be similar but is too poorly known for a meaningful comparison (see also Delpey 1941, fig. 42). *Stegocoelia akasakaensis* Nützel, 2012 from the Middle Permian Akasaka Limestone of Japan is similar but this species is much smaller and the spiral cords have a different position (Nützel & Nakazawa 2012).

***Stegocoelia* sp. 2**
Figure 21C

2014 *Stegocoelia*? sp. 2; Ketwetsuriya *et al.*, p. 145, pl. 2, fig. p.

Material. – One specimen, SNSB-BSPG 2014 XI 94.

Description. – Shell small, high-spired, slender, comprising about 9 whorls, 7.2 mm high, 2.3 mm wide; suture shallow; whorl face straight; whorls ornamented with four distinct spiral cords; adapical spiral cord in subsutural position; second spiral cord somewhat weaker, situated above mid-whorl; third spiral cord strongest, forming periphery, low on the whorl; fourth spiral cord weak, emerging from abapical suture; base flat with angular transition to whorl face.

Remarks. – This shell is poorly preserved but clearly represents a distinct species in the present collection. Similar shells, poorly preserved as well, were reported by Kulas & Batten (1997) as *Stegocoelia* (*Hypergonia*) *percostata* (Girty, 1939) and *Stegocoelia* (*Hypergonia*?) sp. from the Permian of Wyoming. *Stegocoelia turabievoensis* Mazaev, 2001 from the Carboniferous is also similar but much larger.

Family Orthonematidae Nützel & Bandel, 2000

Genus *Orthonema* Meek & Worthen, 1862

Type species. – *Eunema* (?) *salteri* Meek & Worthen, 1860, Carboniferous, USA.

***Orthonema* sp.**
Figure 21A, B

Material. – One specimen, SNSB-BSPG 2014 XI 53.

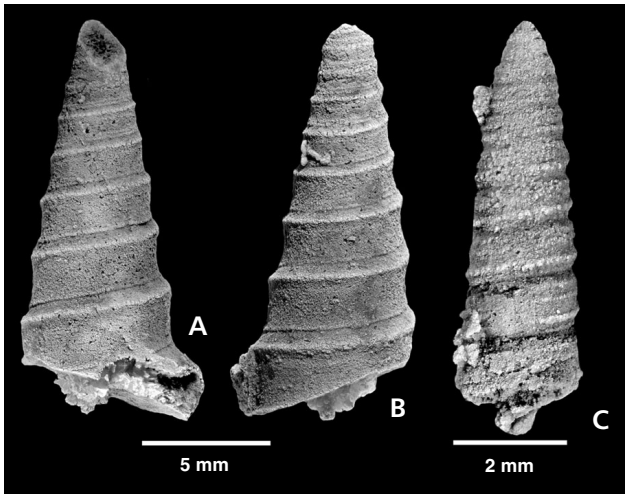

Figure 21. A, B – *Orthonema* sp., SNSB-BSPG 2014 XI 53. • C – *Stegocoelia* sp. 2, SNSB-BSPG 2014 XI 94.

Description. – Shell high-spired, slender, *ca* 8 whorl with apex missing, 16 mm high, 7 mm wide; suture shallow but distinct; whorls largely smooth, ornamented with a distinct, sharp subsutural spiral cord bordering a narrow ramp; abapical spiral lira emerging just at suture; whorl face concave.

Remarks. – This specimen resembles species of the genus *Orthonema* as, for instance, reported from the Carboniferous of Russia (Mazaev 2002) and the Permian of the Southwestern USA (Erwin 1988a).

Genus *Protostylus* Mansuy, 1914a

Type species. – *Protostylus lantenoisi* Mansuy, 1914a, Carboniferous, SE Asia.

Remarks. – Based on Middle Permian high-spired, smooth gastropods, Nützel & Nakazawa (2012) discussed the poorly known genus *Protostylus*. The type species as well as the other species assigned to this genus are poorly preserved and thus, identity and systematics of this genus remain uncertain. Batten (1995) placed *Protostylus* in Procerithiidae based on the presence of an anterior siphonal canal. Nützel *in* Nützel & Nakazawa (2012) placed *Protostylus* tentatively in the family Orthonematidae.

***Protostylus* sp.**
Figure 23A–F

Material. – Five specimens, SNSB-BSPG 2014 XI 40, 56, 74, 99, 114.

Description. – Shell high-spired; largest specimen consists of about 10 whorls, 20 mm high, 6.8 mm wide; sutures distinct; whorls low, slightly convex with periphery somewhat below mid-whorl, embracing low on previous whorl; whorls smooth; base rounded, convex; aperture subovate, somewhat higher than wide.

Remarks. – The present specimens resemble *Protostylus* sp. from the Middle Permian Akasaka Limestone from Japan as reported by Nützel & Nakazawa (2012). However, the Japanese species is somewhat more slender. The studied specimens show a narrow spiral breakage high on the whorls. If this reflects the presence of a selenizone or sinus, this species could be related to genera like *Altadema* Kues, 2002 or *Kazanella* Mazaev, 2015. *Streptacis*? *complanata* Hoare, Sturgeon & Anderson, 1997 from the Pennsylvanian of the USA resembles *Protostylus* sp. and could be a representative of the genus *Protostylus* rather than *Streptacis* – the latter is usually more slender. The Chinese Carboniferous species *Protostylus lantenoisi* Mansuy, 1914a and *P. dussualti* Mansuy, 1914a closely resembles the present species as far as can be inferred from the original illustrations. *Protostylus lantenoisi* has also been reported from the Permian of Perak, Malaysia by Batten (1985).

Superfamily Soleniscoidea Knight, 1931a
Family Soleniscidae Knight, 1931a
Subfamily Soleniscinae Knight, 1931a

Genus *Soleniscus* Meek & Worthen, 1861

Type species. – *Soleniscus typicus* Meek & Worthen, 1861, Carboniferous, USA.

***Soleniscus* sp.**
Figure 22A, B

Material. – One specimen, SNSB-BSPG 2014 XI 120.

Remarks. – This relatively slender, fusiform, smooth soleniscid shell (13 mm high, 4 mm wide) shows a distinct columellar fold. Shells like this have been repeatedly reported from the Late Palaeozoic of the world for instance *Soleniscus variabilis* Erwin, 1988b from the Permian of the USA is quite similar (see also Nützel *et al.* 2000, Batten 1995).

Genus *Strobeus* de Koninck, 1881

Type species. – *Strobeus ventricosus* de Koninck, 1881, Mississippian, Belgium.

***Strobeus* sp.**
Figure 22C, D

Material. – One specimen, SNSB-BSPG 2014 XI 119.

Remarks. – This broad, smooth incomplete soleniscid shell (7.3 mm high, 5.1 mm wide) shows a distinct columellar fold. *Strobeus* is wide-spread and diverse in Late Palaeozoic deposits for instance *Strobeus girtyi* Erwin, 1988b from the Permian of the USA and the Late Permian *Strobeus donglu-oensis* (Pan & Yu, 1993) (see also Nützel & Nakazawa 2012) are similar. However, more and better-preserved specimens are needed for species identification.

Genus *Cylindritopsis* Gemmellaro, 1890

Type species. – *Cylindritopsis ovalis* Gemmellaro, 1890, Permian, Italy.

***Cylindritopsis spheroides* Erwin, 1988b**
Figure 22E–G

1988b *Cylindritopsis spheroides* sp. nov.; Erwin, p. 65, fig. 4.1–4.4.

Material. – One specimen, SNSB-BSPG 2014 XI 52.

Description. – Shell spherical, oval, low-spired, 5.1 mm high, 5.2 mm wide; spire small; whorls smooth, convex, inflated; suture indistinct; aperture crescent shaped, acute adapically, rounded ababically; aperture with two strong columellar folds of equal strength with perpendicular orientation against inner lip; parietal callus present; base evenly rounded, anomphalous.

Remarks. – The present specimen closely resembles *Cylindritopsis spheroides* Erwin, 1988b from the Permian of the southwestern United States. *Cylindritopsis spheroides* could also represent the neritid genus *Oncochilus* Pethö, 1882 (*in* Zittel) which is based on a Jurassic type species. In fact, *Oncochilus* matches *Cylindritopsis spheroides* better than the usually more high-spired *Cylindritopsis*. Yochelson & Saunders (1967) listed two Permian species assigned to *Oncochilus* and stated that the genus was clearly present in the Late Palaeozoic.

Family Meekospiridae Knight, 1956

Genus *Meekospira* Ulrich, *in* Ulrich & Scofield, 1897

Type species. – *Eulima peracuta* Meek & Worthen, 1861, Carboniferous, USA.

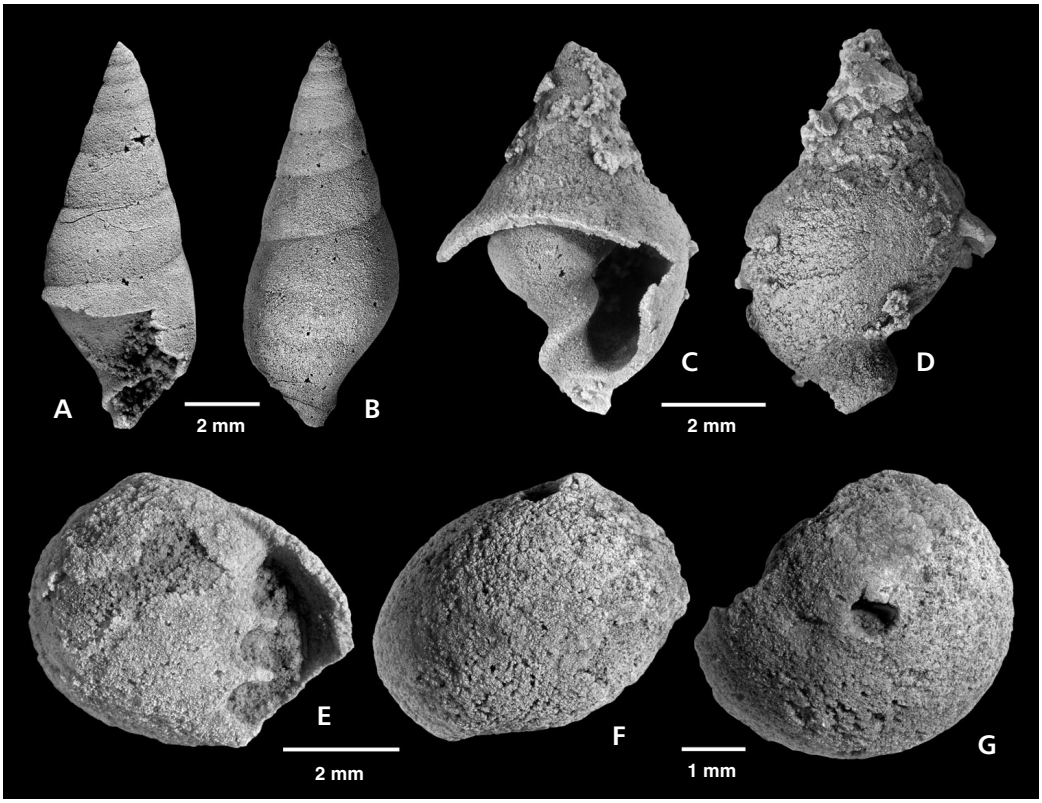

Figure 22. A, B – *Soleniscus* sp., SNSB-BSPG 2014 XI 120. • C, D – *Strobeus*? sp., SNSB-BSPG 2014 XI 119. • E–G – *Cylindritopsis spheroides* Erwin, 1988b, SNSB-BSPG 2014 XI 52.

***Meekospira* sp.**
Figure 23G

2014 *Meekospira* sp.; Ketwetsuriya *et al.*, p. 144, pl. 2, fig. m.

Material. – One specimen, SNSB-BSPG 2014 XI 7.

Remarks. – This single slender fusiform shell (7.8 mm high, 5.8 mm high) with straight flanks and slightly convex, smooth whorls is a typical representative of the genus *Meekospira* which is widespread and diverse in the Late Palaeozoic (*e.g.*, Knight 1932, Erwin 1988b, Nützel *et al.* 2000). *Meekospira melanoides* and *M. ligonensis*, both described by Batten (1985) from the Permian of Perak, Malaysia are more slender and have higher whorls.

Genus *Ceraunocochlis* Knight, 1931a

Type species. – *Ceraunocochlis fulminula* Knight, 1931a, Pennsylvanian, USA.

***Ceraunocochlis* sp.**
Figure 23H

Material. – One specimen, SNSB-BSPG 2014 XI 78.

Description. – Cigar-shaped shell, slender, high-spired, asymmetrical, with convex flank opposed to a to slightly concave flank; shell comprising *ca* 7 whorls, 5.1 mm high, 1.4 mm wide; last whorl incomplete but seemingly slightly constricted; whorls high, smooth; suture obscure, very shallow; whorl face almost straight; aperture not preserved.

Remarks. – The generic assignment of this specimen is beyond doubt. It resembles *Ceraunocochlis fulminula* Knight, 1931a from the Pennsylvanian of the USA and *Ceraunocochlis* sp. as reported by Nützel & Nakazawa (2012) from the Middle Permian Akasaka Limestone, Japan.

Genus *Cambodgia* Mansuy, 1914b

Type species. – *Cambodgia sinsistrorsa* Mansuy, 1914b, Permian, Cambodia.

***Cambodgia acuminata* sp. nov.**
Figure 24A–C

2014 *Cambodgia* cf. *sinistrorsa* Mansuy, 1914b. – Ketwetsuriya *et al.*, p. 144, pl. 2, fig. l.

Locus typicus. – Khao Noi hill, Takhli district, Southeast of Nakhon Sawan province, *ca* 80 km south of Nakhon Sawan City, Northern Thailand, 15° 18´ 51.801˝ N, 100° 26´ 30.358˝ E (Fig. 1).

Stratum typicum. – Tak Fa Formation of the Saraburi Group, Middle Permian, Wordian.

Material. – Four specimens, holotype: SNSB-BSPG 2014 XI 98, paratypes: SNSB-BSPG 2014 XI 54, 117, CUMZ 7017.

Etymology. – Latin needle-shaped, acute.

Description. – Shell sinistral, small, high-spired, very slender with an apical angel of less than 30° and numerous whorls; largest specimen comprising 9 whorls with apex missing, 12.7 mm high, 3.3 mm wide; holotype comprising *ca* 14 whorls, 7.4 mm high, 4.0 mm wide; early shell slightly coeloconoid; whorls smooth, weakly convex; sutures shallow but distinct; aperture unknown.

Remarks. – The sinistral species *Cambodgia acuminata* sp. nov. is extremely needle-shaped. It resembles *Cambodgia sinistrorsa* Mansuy, 1914b from the Permian Productus Limestone of Cambodia. However, *Cambodgia acuminata* sp. nov. is much more slender. The sinistral, needle-shaped species *Methorthonema sinistrale* Erwin, 1988a from the Early Permian of the Soutwestern USA is more pronouncedly coeloconoid in the early whorls and later whorls are straight-sided so that the teleoconch is almost cylindrical which is not the case in *Cambodgia acuminata* sp. nov.

Family Palaeostylidae Wenz, 1938

Genus *Trepsipleura* Kues, 2002

Type species. – *Trepsipleura chordanodosa* Kues, 2002, Pennsylvanian, USA.

Remarks. – Kues (2002) discussed the assignment of *Trepsipleura* and placed it in Pseudozygopleuridae Knight, 1930 but also discussed a possible assignment to Palaeozygopleuridae. We think that an assignment to Palaeostylidae is the better choice because of the low whorls and the lack of the typical pseudozygopleurid larval shell as far as it is known [shown for *Palaeozygopleura*? *perversa* (Knight, 1930) by Nützel 1998]. Synonymy of the three species *Palaeozygopleura*? *perversa* (Knight, 1930), *Palaeostylus*? (*Pseudozygopleura*) *bella* Carew, 1980 and *Trepsipleura chordanodosa* Kues, 2002 seems to be possible. The sinistral species *Palaeozygopleura retroflexa* Licharev, 1968 is distinct by having a denser ribbing.

***Trepsipleura chordanodosa* Kues, 2002**
Figure 24D, E

2014 *Palaeostylus* sp.; Ketwetsuriya *et al.*, p. 144, pl. 2, fig. n.

Material. – Two specimens, SNSB-BSPG 2014 XI 1, 112.

Description. – Shell sinistral, high-spired, cyrtoconoid; larger specimen is 12.9 mm high, 3.7 mm wide; whorls low, rounded quadrangular in transverse section; whorls slightly convex; sutures distinct; whorls ornamented with strong, straight to slightly opisthocyrt, broad, rounded axial ribs, numbering about 12–16 per whorl presumably reduced on the last whorls; aperture with indistinct siphonal notch.

Remarks. – The present specimens closely resemble the Middle Pennsylvanian *Trepsipleura chordanodosa* from West Texas so that the present material is identified with this species despite the considerable difference in age. Other similar sinistral species with zygopleuroid habitus are *Palaeozygopleura*? *perversa* (Knight, 1930) from the Pennsylvanian of the USA (see Nützel 1998) and *Palaeostylus*? (*Pseudozygopleura*) *bella* Carew, 1980 from the Pennsylvanian of Texas.

Superfamily Zygopleuroidea Wenz, 1938
Family Pseudozygopleuridae Knight, 1930

Genus *Pseudozygopleura* Knight, 1930

***Pseudozygopleura*? sp.**
Figure 24F

Material. – One specimen, SNSB-BSPG 2014 XI 55.

Description. – Shell high-spired to fusiform, comprising *ca* 6 whorls, 12.6 mm high, 5.3 mm wide; whorls convex with strong axial ribs numbering about 14 to 16 per whorl; ribs round, as wide as interspaces, distinctly prosocline; ribs reduced on last preserved whorl; suture distinct; base rounded, anomphalous.

Remarks. – The present shell with zygopleuroid morphology could represent the diverse Late Palaeozoic gastropod family Pseudozygopleuridae but knowledge of the protoconch is needed for a meaningful taxonomic treatment.

Subclass Heterobranchia Burmeister, 1837
Superfamily Streptacidoidea Knight, 1931b
Family Streptacididae Knight, 1931b

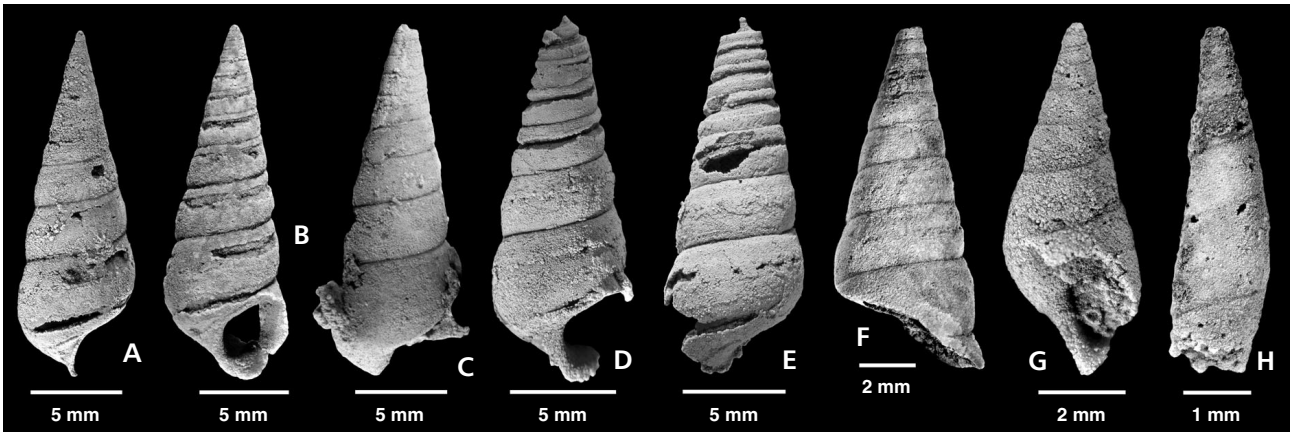

Figure 23. A – *Protostylus* sp., SNSB-BSPG 2014 XI 40. • B – *Protostylus* sp., SNSB-BSPG 2014 XI 56. • C – *Protostylus* sp., SNSB-BSPG 2014 XI 99. • D, E – *Protostylus* sp., SNSB-BSPG 2014 XI 114. • F – *Protostylus* sp., SNSB-BSPG 2014 XI 74. • G – *Meekospira* sp., SNSB-BSPG 2014 XI 7. • H – *Ceraunocochlis* sp., SNSB-BSPG 2014 XI 78.

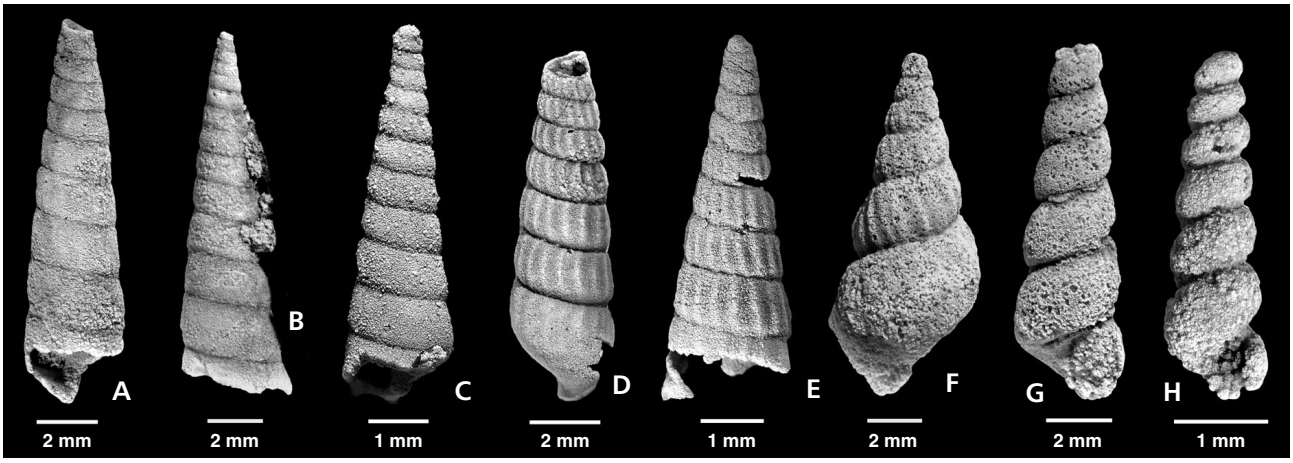

Figure 24. A – *Cambodgia acuminata* sp. nov., paratype, SNSB-BSPG 2014 XI 54. • B – *Cambodgia acuminata* sp. nov., holotype, SNSB-BSPG 2014 XI 98. • C – *Cambodgia acuminata* sp. nov., paratype, SNSB-BSPG 2014 XI 117. • D – *Trepsipleura chordanodosa* Kues, 2002, SNSB-BSPG 2014 XI 1. • E – *Trepsipleura chordanodosa* Kues, 2002, SNSB-BSPG 2014 XI 112. • F – *Pseudozygopleura*? sp., SNSB-BSPG 2014 XI 55. • G – *Streptacis*? sp., SNSB-BSPG 2014 XI 51. • H – *Streptacis*? sp., SNSB-BSPG 2014 XI 71.

Genus *Streptacis* Meek, 1871

Type species. – *Streptacis whitfieldi* Meek, 1871, Carboniferous, USA.

***Streptacis*? sp.**
Figure 24G, H

Material. – Two specimens, SNSB-BSPG 2014 XI 51, 71.

Description. – Shell high-spired, slender; larger specimen 11.3 mm high (apex missing), 3.5 mm wide; whorls smooth, strongly convex; suture impressed; base convex, rounded.

Remarks. – High-spired, small, smooth shells like the present ones have been commonly reported from Late Palaeozoic deposits of the world, for instance *Streptacis whitfieldi* Meek, 1871 from the Carboniferous of the USA and *Streptacis orientalis* Nützel, 2012 as well as *Streptacis*? sp. from the Middle Permian Akasaka Limestone of Japan (Nützel & Nakazawa 2012).

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