

New records of nautiloid and ammonoid cephalopod fossils in peninsular Thailand

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Abstract Thirty species of nautiloids and ammonoids were identified based on the material collected from peninsular Thailand. Ordovician nautiloids: a sactorthoceratid nautiloid (*Sactorthoceras banestanensis*) from Changwat Satun, from the western part of the peninsula and a ruedemannoceratid nautiloid (*Mediganella magna*), from Changwat Nakhon Si Thammarat from the eastern part of the peninsula. Devonian-Carboniferous ammonoid: *Neoglyphioceras subcirculare* from Changwat Satun. Triassic nautiloids: two orthoceratid nautiloids (*Michelinoceras* sp. A and *Tienoceras* sp. A), and two syringonautilid nautiloids (*Syringoceras barrandei* and *Javavionautilus heterophyllus*) from Changwat Phatthalung, in the eastern part of the Peninsula. Twenty-four species of ammonoids were collected from the same locality: one ophiceratid (*Ophiceras connectens*), one flemingitid (*Xenodiscoides perplicatus*), one meekoceratid (*Juvenites canadensis*), two paranannitids (*Arianites musacchi* and *Epichelites genfii*), two ussuriids (*Ussuria* sp.

A and *Ussaria* sp. indet.), one noritid (*Bosnites clathratus*), one acrochordiceratid (*Paracrochordiceras* sp. indet.), nine ceratitids (*Kellnerites bosnensis*, *Halilucites* sp. A, *Halilucites* sp. B, *Eutomoceras* aff. *laubei*, *E. dunni*, *Eutomoceras* sp. A, *E. sp. B*, *E. sp. C*, *E. sp. D*), one hungaritid (*Hungarites* sp. A), one aplococeratid (*Aplococeras parrus*), one celtitid (*Indoceltites trigonalis*), one nannolytoceratid (*Audaxlytoceras audax*) and one protetragonitid (*Protetragonites* sp. A). All these cephalopods are recorded for the first time in Thailand.

Keywords New records · Nautiloid · Ammonoid · Cephalopod · Fossil · Peninsular Thailand

Introduction

The peninsular Thailand is the center of the Shan-Thai block (Bunopas and Vella 1983). The Paleozoic and Mesozoic rocks in peninsular Thailand are the Phuket Mountain range and the Nakhon Si Thammarat Mountain range (Fig. 1), distributed in the north–south axis along the peninsula. Cambrian rocks are present in the southwestern coast of the peninsula, on Tarutao Islands and Changwat Satun on mainland (Pungrassami 1983; Wongwanich et al. 2002; Cocks et al. 2005). The Ordovician Rocks are shales and limestones of deep-water facies, which are 900–1040 m thick and occur in the lower part of the peninsula (DMR 2013). The system consists mainly of the carbonatic Thung Song Group which can be subdivided into seven formations (Wongwanich et al. 1983, 1990; DMR 2001; DMR 2013). The Rung Nok Formation is Early to Middle Ordovician and occurs in Thung Song, Changwat Nakhon Si Thammarat (10°N, 99°E) (the fourth locality of this study) in the

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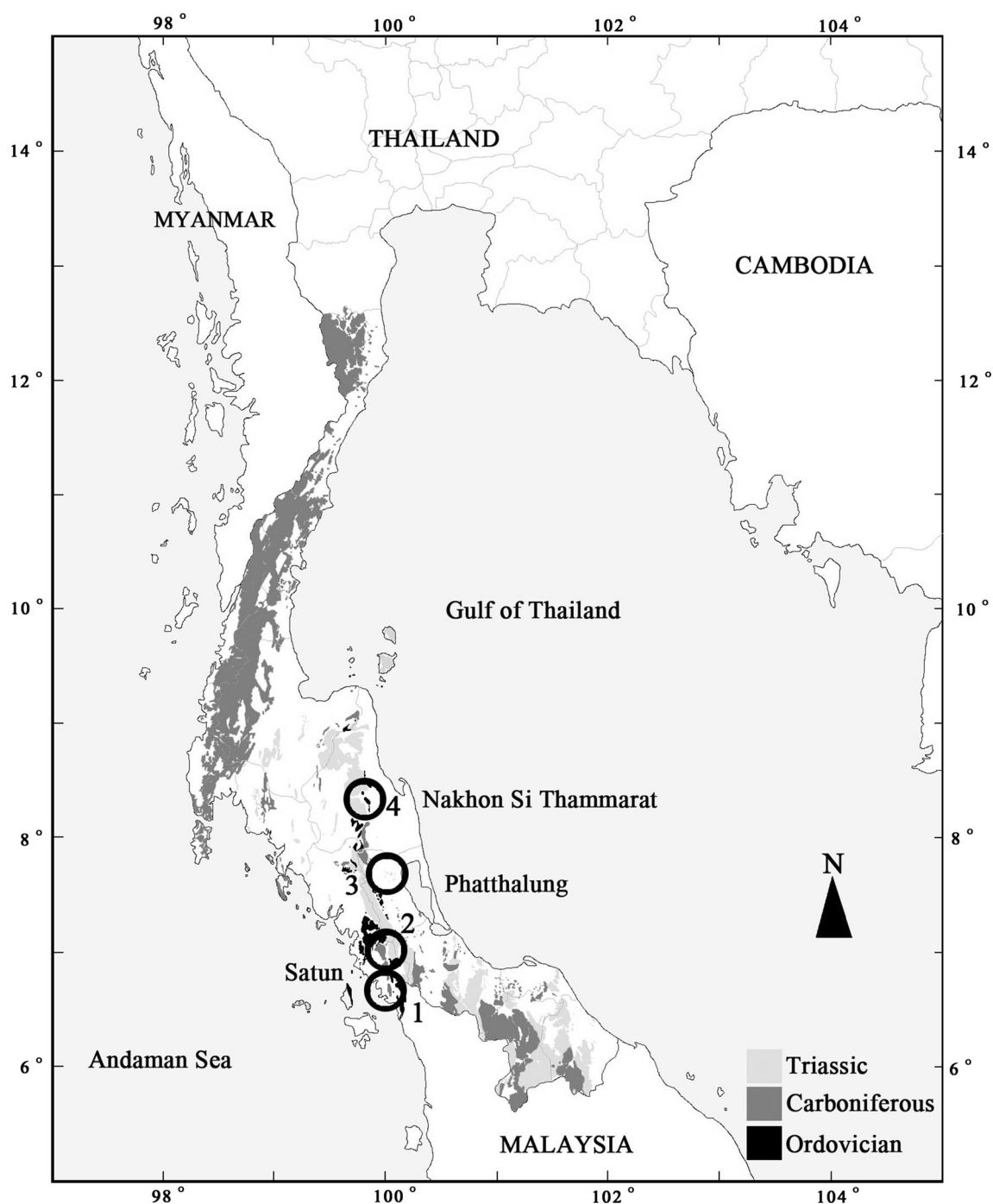


Fig. 1 Localities considered in the present study in peninsular Thailand: 1 Khao Banhan, Changwat Satun; 2 Khao Noi, Changwat Satun; 3 Khao Ok-thalu, Changwat Phatthalung; 4 Khao Phanomsherd, Changwat Nakhon Si Thammarat (modified from: DMR 2001)

northeastern part of the peninsula and La-gnu, Changwat Satun in the southwest (6°N, 102°E). The uppermost Ordovician strata presented at the latter locality have been proposed as Pa Kae Formation (Wongwanich et al. 1983; DMR 2001) (Table 1). The Ordovician and Silurian

boundary is about 10 km away in the Thong Pha Phum Group (the first locality). The nautiloid *Manchuroceras* has been recorded from the Ordovician carbonate in the peninsula (Stait and Burrett 1984). No Ordovician fossils younger than Whiterockian were found.

Table 1 Stratigraphic chart of the study region, Ordovician to Triassic of Changwat Satun, Changwat Nakhon Si Thammarat and Changwat Phatthalung in peninsular Thailand (DMR 2013)

Period	Age	Group	Formation
U. Triassic	L. to M. Norian	Lampang	Chaiburi
L. to M. Triassic	Spathian to Anisian		Phanomwang Limestone Member
	Dienerian to Spathian		Chiak Limestone Member
			Phukhaothong Dolomite Member
L. Devonian to L. Carboniferous	Namurian	Thong Pha Phum	Pa Samed
U. Silurian to L. Devonian	–		Kuan Tung
U. Ordovician to L. Silurian	U. Ashgillian to Llandovery		Wang Tong
U. Ordovician	Caradocian to L. Ashgillian	Thung Song	Pa Kae
L. Ordovician	M. to U. Arenigian		Rung Nok
	M. Arenigian		Lae Tong
	L. Arenigian		Pa Nan
			La Nga
	U. Tremadocian		Talo Dang
			Malaka

The Thong Pha Phum Group in the lower part of the peninsula consists of sandy marl, black shale, calcareous siltstone and nodular limestone (Bunopas 1983; DMR 2013). The age of this group is still uncertain (DMR 2001). The group is subdivided into three formations (Table 1) with uncertain age; Wang Tong Formation of Late Ordovician to Early Silurian age, Kuan Tang Formation of Late Silurian to Early Devonian age and Pa Samed Formation of Early Devonian to Early Carboniferous age (Bunopas 1983; Wongwanich et al. 1990) (the second locality). Cephalopod fossils have been recorded in the upper member of the shallow-water facies.

The Lampang Group is Permian with the Phanom Wang Formation, which crops out in the east-central part of the peninsula (Chonglakmani 1983; Raksakulwong 2002). Nautiloids have been recorded from Permian Rocks. Chaiburi Formation is the only Triassic stratigraphic unit of this group (Ampornmaha 1995); it occurs only in Changwat Phatthalung (the third locality). This formation consists of three members (Table 1); Phukhaothong Dolomite, Chiak Limestone and Phanomwang Limestone Members (Ampornmaha 1995; Sardud 2001; Meesook et al. 2002; DMR 2013). Fossils of conodonts, radiolarians and early reptiles have been recorded from these carbonate formations (Ampornmaha 1995; Bunopas 1983; Sardud 1997, 2001, 2002).

Cephalopod fossils in Thailand, especially in peninsular Thailand are known from only a few localities. The first record was about three species of Carboniferous ammonoids by Reed (1920). At present, the cephalopods recorded from Thailand comprise some 133 species (Reed 1920; Brown et al. 1951; Kummel 1960; Pitakpaiwan et al. 1969; Teraoka

et al. 1982; Chonglakmani 1983; Stait and Burrett 1984; Glenister et al. 1990; Ishibashi and Chonglakmani 1990; Ingavat-Helmcke 1994; Ishibashi et al. 1997; Fujikawa et al. 1999, 2005; Fujikawa and Ishibashi 2000; Wongwanich et al. 2004; Zhou and Liengjarere 2004; DMR 2006; Hirsch et al. 2008; Ridd et al. 2011; Kozai et al. 2011). The nautiloids found in Thailand belong to 4 subclasses, 6 orders, 11 families, 15 genera and 21 species. Ammonoids discovered in Thailand were assigned to 1 subclass, 5 orders, 40 families, 71 genera and 112 species. Of these 133 species recorded in Thailand, only 14 of nautiloids and 10 of ammonoids are from peninsular Thailand.

In peninsular Thailand, the previous records of fossil cephalopods were distributed over 24 species. Nautiloids have been recorded only from the Ordovician and ammonoids from the Carboniferous and Permian. The first record of nautiloids was *Actinoceras* sp. from Changwat Nakhon Si Thammarat, in the eastern part of the peninsula (Brown et al. 1951). Pitakpaiwan et al. (1969) reported *Armenoceras* cf. *chediforme* Kobayashi, 1958 from the same locality (including three unidentified Middle Ordovician nautiloids) Changwat Satun, in the western part of the peninsula. Changwat Satun has been the source locality for several nautiloids: *Michelinoceras* sp., *Sinoceras chinense* (Foord, 1888) (Stait and Burrett 1984), one endoceroid from the Thung Song Formation (Teraoka et al. 1982), *Wutinoceras* sp., Endoceratidae indet., *Chaohuceras* sp., *Hardmanoceras chrysanthemum* (Kobayashi, 1959), *Machuroceras nakamense* Stait and Burrett, 1984 (Stait and Burrett 1984; DMR 2006), *Actinoceras* sp., *Armenoceras* sp., *Georgina* sp. and one ormocerid. (Ingavat-Helmcke 1994).

The first cephalopods recorded in peninsular Thailand were Carboniferous ammonoids from Changwat Phatthalung in the eastern part of the peninsular, described by Reed (1920) as *Glyphioceras?* sp., *Prolecanites?* sp. and *Pronorites* aff. *cyclolobus* (Phillips, 1836). Wongwanich et al. (2004) recorded *Syngastrioceras* sp. and *Stenopronorites* aff. *uralensis* (Karpinsky, 1889) from the Lower Carboniferous of Changwat Satun. From the Lower Permian, Fujikawa et al. (2005) reported five ammonoids from Changwat Phatthalung, *Agathiceras* aff. *suessi* Gemmellaro, 1887, *A. girtyi* (Bose), *Agathiceras?* sp., *Adrianites* sp. and *Miklukhoceras* sp.

Since most palaeontological studies in Thailand have been focused on macro-vertebrates, dinosaurs and fish, the authors aim to raise the renewed interests in fossil invertebrate systematics. This study focuses on taxonomic identification and the description of diversity of cephalopod fossils of the region. However, available materials, particularly ammonoids, are limited to the Ordovician to Triassic, excluding the Permian, Jurassic and Cretaceous and Cenozoic. Therefore, it does not represent the majority of cephalopods diversity in the region. Much more materials are to be discovered and much more publications will follow.

Thai words used in the text are Khao (=Mountain), Muang (=City), Amphoe (=District) and Changwat (=Province).

Materials and methods

The materials are from unsorted collections of the Palaeontological Research and Education Center, Mahasarakham University (PRC), Changwat Mahasarakham (northeastern Thailand); Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University (PSUNHM), Changwat Songkhla (southeastern Thailand); and Natural History Museum, Kampanwitaya School (ISI), Changwat Satun (southwestern Thailand). Specimens of PRC and PSUNHM were collected by the third author (PS) during 1973–1974 as unidentified outcrop fossils. Specimens of ISI were collected from Changwat Satun by the fourth author (TN) in 2004.

A total of 808 specimens of nautiloids and ammonoids were collected from four localities in peninsular Thailand (Fig. 1). The first locality is Khao Noi (06°58'N, 99°46'E), Amphoe Langu, Changwat Satun. The Upper Ordovician (Caradocian to Ashgillian) deposits are included in the Pa Kae Formation, Thung Song Group. The second locality is Khao Banhan (6°56'N 99°47'E) in Ban Han, Amphoe Langu, Changwat Satun, Lower Carboniferous (Table 1) deposits are included in the Pa Samed Formation, Thong

Pha Phum Group. These two localities are in the western part of the peninsula on the Andaman Sea coast, Indian Ocean. The third locality is Khao Ok-thalu (07°37'N, 100°5'E), Amphoe Muang Phatthalung, Changwat Phatthalung, Phukhaothong Dolomite, Chaiburi Formation, Lampang Group, Early to Middle Triassic (Anisian) (Ampornmaha 1995). The fourth locality is Khao Phanomsherd (08°09'N, 99°51'E), Amphoe Ronphibun, Changwat Nakhonsrithammarat, Rung Nok Formation, Thung Song Group, Lower Ordovician (Arenigian). The two latter localities are in the eastern part of the peninsula on the Gulf of Thailand coast, South China Sea, Pacific Ocean.

The terminology of morphology and measurements essentially follows Arkell et al. (1957) and Teichert et al. (1964). The description of nautiloids was made using the following abbreviations: (Pl) Phragmocone length, (Paw) Phragmocone anterior width, (Ppw) Phragmocone posterior width, (Cl) Chamber length, (Spd) Siphuncle diameter, and (Sl) Septal neck length. The description of the ammonoids was made using the following abbreviations: (Md) Maximum diameter, (Wh) Whorl height, (Ww) Whorl width, and (Ud) Umbilical diameter.

All specimens have been deposited in the reference Collection of the Palaeontological Research and Education Center, Mahasarakham University (PRC) and the Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University (PSUNHM) and the Natural History Museum, Kampanwitaya School, (ISI).

Systematic paleontology (Table 2)

Subclass Orthoceratoidea Kuhn, 1940.

Order Orthocerida Kuhn, 1940.

Family Orthoceratidae Kuhn, 1940.

Genus *Michelinoceras* Foerste, 1932.

Type species: Orthoceras michelini Barrande, 1866.

Michelinoceras sp. A

(Fig. 2a, b)

Material: 1 specimen (PRC-SHM-KO-121); phragmocone length 82.1 mm, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: The specimen cannot be identified to species level because only one chamber of the phragmocone is preserved and the internal characters are incomplete (a perforate chamber and septal neck of the siphuncle are preserved).

Table 2 New records of fossil cephalopods in peninsular Thailand presented herein

Taxa	Strata		
	Ordovician	Carboniferous	Triassic
Subclass Orthoceratoidea Kuhn, 1940			
Order Orthocerida Kuhn, 1940			
Family Orthoceratidae Kuhn, 1940			
1. <i>Michelinoceras</i> sp. A			+
2. <i>Tienoceras</i> sp. A			+
Family Sactorthoceratidae Flower, 1946			
3. <i>Sactorthoceras banestanensis</i> Evans, 2006	+		
Subclass Nautiloidea Agassiz, 1847			
Order Discosorida Flower in Flower and Kummel, 1950			
Family Ruedemannoceratidae Flower, 1940			
4. <i>Madiganella magna</i> Teichert and Glenister, 1952	+		
Order Nautilida Agassiz, 1847			
Family Syringonautilidae Mojsisovics, 1902			
5. <i>Syringoceras barrandei</i> (Hauer, 1847)			+
6. <i>Javavionautilus heterophyllus</i> (Hauer, 1849)			+
Subclass Ammonoidea Zittel, 1884			
Suborder Goniatitina Hyatt, 1884			
Family Goniatitidae de Haan, 1825			
7. <i>Neoglyphioceras subcirculare</i> (Miller, 1889)		+	
Suborder Ceratitina Hyatt, 1884			
Family Ophiceratidae Arthaber, 1911			
8. <i>Ophiceras connectens</i> Schindewolf, 1954			+
Family Flemingitidae Hyatt, 1900			
9. <i>Xenodiscoides perplicatus</i> (Frech, 1905)			+
Family Meekoceratidea Waagen 1895			
10. <i>Juvenites canadensis</i> (Tozer 1961)			+
Family Paranannitidae Spath, 1930			
11. <i>Arianites musacchi</i> Arthaber, 1911			+
12. <i>Epiceltites genfii</i> Arthaber, 1911			+
Family Ussuridae Spath, 1930			
13. <i>Ussuria</i> sp. A			+
14. <i>Ussuria</i> sp. indet.			+
Family Noritidae Karpinsky, 1889			
15. <i>Bosnites clathratus</i> Hauer, 1897			+
Family Acrochordiceratidae Arthaber, 1911			
16. <i>Paracrochordiceras</i> sp. indet.			+
Family Ceratitidae Mojsisovics, 1879			
17. <i>Kellnerites bosnensis</i> (Hauer, 1888)			+
18. <i>Halilucites</i> sp. A			+
19. <i>Halilucites</i> sp. B			+
20. <i>Eutomoceras</i> aff. <i>laubei</i> Meek, 1877			+
21. <i>Eutomoceras dunni</i> Smith, 1904			+
22. <i>Eutomoceras</i> sp. A			+
23. <i>Eutomoceras</i> sp. B			+
24. <i>Eutomoceras</i> sp. C			+
25. <i>Eutomoceras</i> sp. D			+
Family Hungaritidae Waagen, 1895			
26. <i>Hungarites</i> sp. A			+

Table 2 continued

Taxa	Strata		
	Ordovician	Carboniferous	Triassic
Family Aplococeratidae Spath, 1951			
27. <i>Aplococeras parvus</i> (Smith 1914)			+
Family Celtitidae Mojsisovics, 1893			
28. <i>Indoceltites trigonalis</i> (Diener, 1908)			+
Suborder Lytoceratina Hyatt, 1889			
Family Nannolytoceratidae Spath, 1927			
29. <i>Audaxlytoceras audax</i> Meneghini, 1881			+
Family Protetragonitidae Spath, 1927			
30. <i>Protetragonites crebrisulcatus</i> (Uhlig, 1883)			+

Genus *Tienoceras* Chao 1954.

Type specie: Tienoceras lenticulare Chao 1954.

Tienoceras sp.

A (Fig. 2c–h)

Material: 1 specimen (PRC-SKM-KO-151), phragmocone length 17 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: The present Early Triassic specimen differed from *T. lenticulare* Chao 1954, Permian, in its flatter and depressed round shape of the dorso-ventral cross section and the central position of the siphuncle compared to the lenticular cross section and subcentral siphuncle of *T. lenticulare* (Chao 1954).

Family Sactorthoceratidae Flower, 1946.

Genus *Sactorthoceras* Kobayashi, 1934.

Type species: Sactorthoceras gonioseptum Kobayashi, 1934.

Sactorthoceras banestanensis Evans, 2006

(Fig. 2i, j)

2006 *Sactorthoceras* cf. *banestanensis* Evans, Evans in Danstanpour et al., Fig. 2, p. 340, Fig. 3, p. 343.

Material: 1 specimen (ISS-LN-ST-024), phragmocone length 69 mm, Pa Kae Formation, Thungsong Group, Ordovician, Khao Noi, Changwat Satun, 6°58'N, 99°46'E, collector T. Nutadhira.

Remarks: The present specimen is similar to *S. banestanensis* Evan, 2006 from the late Early Ordovician

(Caradoccian) of Kerman, East-Central Iran (Dastanpour et al. 2006, Fig. 3, p. 343). However, the size of the septal foramen of the present specimen was smaller (5.5 vs. 13.3 %), while the chamber length was longer (19 vs. 15 %) and the septal neck was longer (6 vs. 3.7 %).

Subclass Nautiloidea Agassiz, 1847.

Order Discosorida Flower, 1950.

Family Ruedemannoceratidae Flower, 1940.

Genus *Madiganella* Teichert and Glenister, 1952.

Type species: Madiganella magna Teichert and Glenister, 1952.

Madiganella magna Teichert and Glenister, 1952

(Fig. 2k, l)

1957. *Madiganella magna*; Flower and Teichert, pl. 4, Fig. 7, p. 24.

1964. *Madiganella magna*; Teichert et al., Fig. 2a, b, p. K329.

Material: 2 specimens (PRC-SHM-KPC-002 and 003), phragmocone length 23.3–31.0 mm, Rung Nok Formation, Thungsong Group, Ordovician, Khao Phanom-Sherd, Changwat Nakhon Si Thammarat, 8°09'N, 99°51'E, collector P. Srisuk.

Remarks: The chamber length of *M. magna* (see Teichert et al. 1964; Fig. 2a, b, K329) is about 10.7 % of the phragmocone width, but that of the present specimen is about 5.3 %.

Order Nautilida Agassiz, 1847.

Family Syringonaulitidae Mojsisovics, 1902.

Genus: *Syringoceras* Hyatt, 1894.

Type species: Ammonites? granulosostratus Klipstein, 1843.

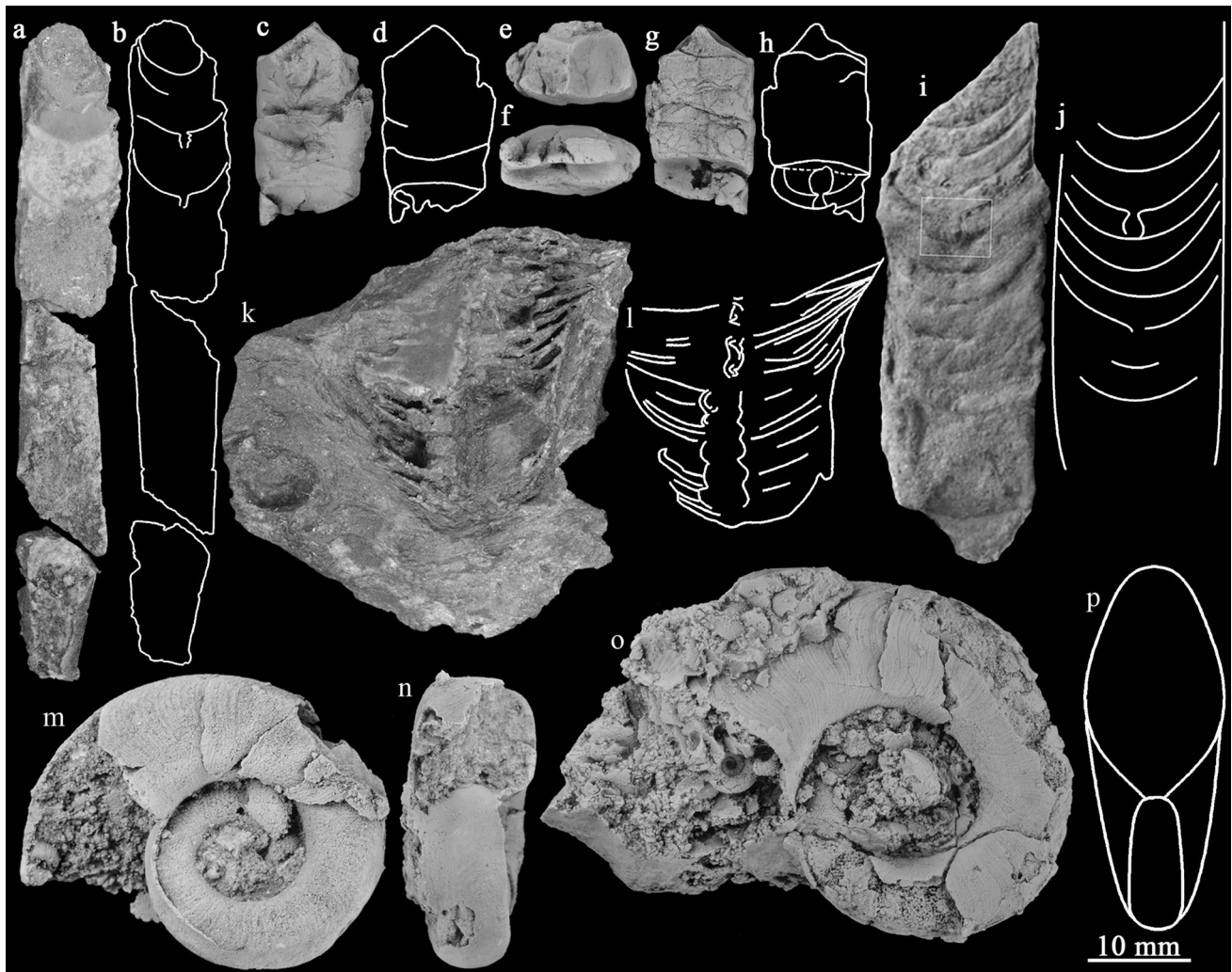


Fig. 2 a, b *Michelinoceras* sp. A; PRC-SHM-KO-121, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, lateral view; c–h *Tienoceras* sp. A; PRC-SHM-KO-151, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, c, d dorsal view, e anterior cross section, f posterior cross section, g, h ventral view; i–j *Sactorthoceras banestanensis* Evan, 2006; ISS-LN-ST-024, Pa Kae Formation, Ordovician, 6°58'N, 99°46'E, lateral view; k, l *Madiganella magna* Teichert and Glenister,

1952; PRC-SHM-KPC-002, Rung Nok Formation, Ordovician, 8°09'N, 99°51'E, lateral view; m, n *Syringoceras barrandei* (Hauer, 1847); PRC-SHM-KO-056, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, m lateral view, n rectangular cross section; o, p *Juvavionautilus heterophyllus* (Hauer, 1849); PRC-SHM-KO-055, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, o lateral view, p cross section with acute venter

Syringoceras barrandei (Hauer, 1847)
(Fig. 2m, n)

1953 *Syringoceras barrandei*; Kummel, Fig. 30D, p. 62; Mojsisovics 1902, pl. 5, Fig. 2b.
1911 *Syringoceras barrandei*; Renz, Fig. 14, p. 91.

Material: 1 specimen (PRC-SHM-KO-056), diameter 39 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P Srisuk.

Genus *Juvavionautilus* Mojsisovics, 1902.
Type species: *Nautilus heterophyllus* Hauer 1849.

Juvavionautilus heterophyllus (Hauer, 1849)
(Fig. 2o, p)

1953 *Juvavionautilus heterophyllus*; Kummel, Fig. 32, C, p. 64, pl. 18, Figs. 1–2, p. 140.

Material: Three specimens (PRC-SHM-KO-055, 110, 112), diameter 53 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Subclass Ammonoidea Zittel, 1884.
Order Goniatitida Hyatt, 1884.

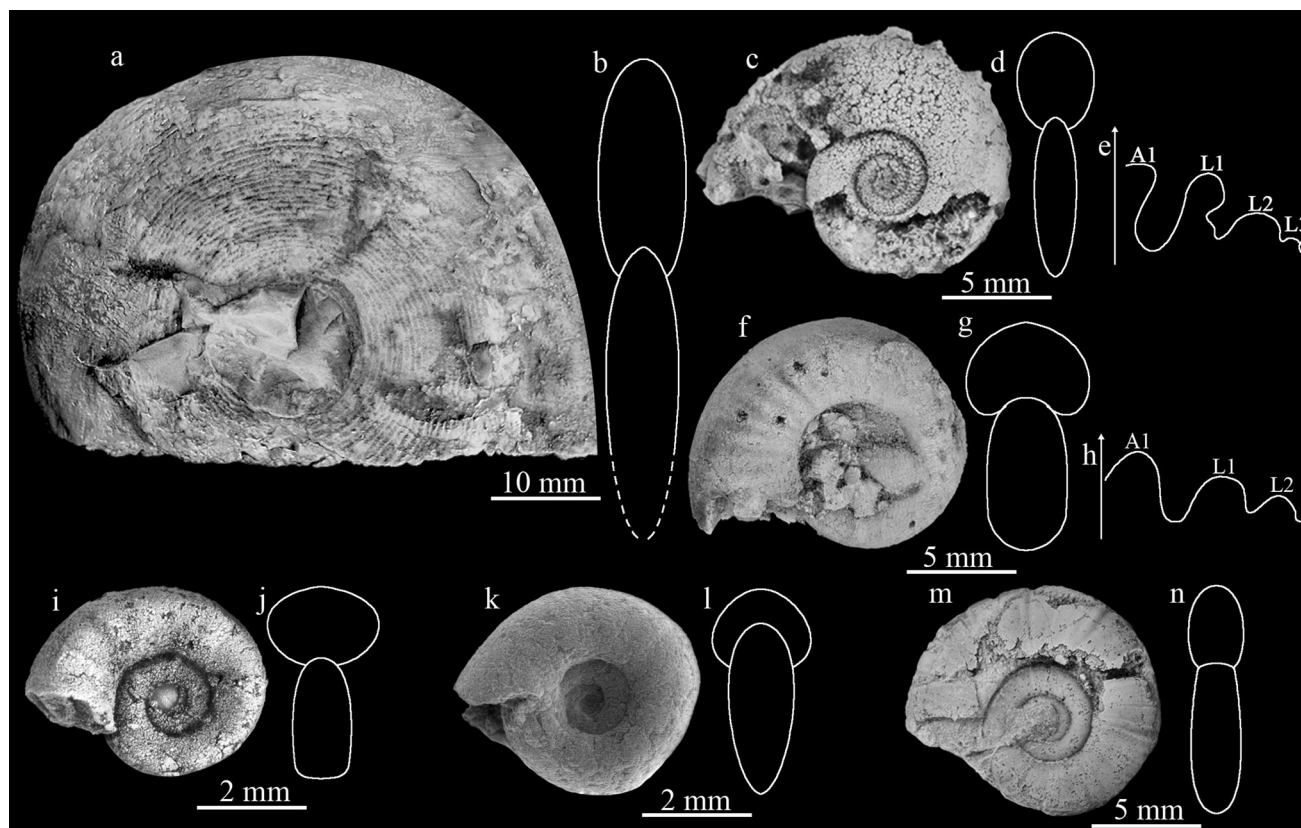


Fig. 3 a–b *Neoglyphioceras subcirculare* (Miller, 1981); ISS-LN-ST-025, Pa samed Formation, Late Ordovician, 6°56'N, 99°47'E, a lateral view, lirae on surface, b cross section; c–e *Ophiceras connectens* Schindewolf, 1954; PRC-SHM-KO-138, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, c lateral view, d cross section, e ceratitic suture; f–h *Xenodiscoides perplicatus* (Frech, 1905); PRC-SHM-KO-060, Chaiburi Formation, Triassic, 7°37'N, 100°5'E,

f lateral view, g cross section, h ceratitic suture; i, j *Juvenites canadensis* (Tozer, 1961); PRC-SHM-KO-081, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, i lateral view, j cross section; k, l *Arianites musacchi* Arthaber, 1911; PRC-SHM-KO-207, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, k lateral view, l cross section; m, n *Epiceltites genfii* Arthaber, 1911; PRC-SHM-KO-061, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, m lateral view; n cross section

Suborder Goniatitina Hyatt, 1884.

Family Goniatitidae de Haan, 1825.

Genus *Neoglyphioceras* Brüning, 1923.

Type species: *Goniatites spiralis* Phillips, 1841.

Neoglyphioceras subcirculare (Miller, 1889)

(Fig. 3a, b)

1957 *Neoglyphioceras subcirculare*; Arkell et al., Fig. 73, p. L59.

1964 *Neoglyphioceras subcirculare*; Gordon, pl. 20, Figs. 28–44, Figs. 50A, G, 51B.

1971 *Neoglyphioceras subcirculare*; Furnish et al., pl. 1, Figs. 8–16, p. 11.

Material: One specimen (ISS-LN-ST-025), diameter 80.0 mm, Pa samed Formation, Thong Phaphum Group, Late Ordovician, Khao Banhan, Changwat Satun, 6°56'N, 99°47'E, collector T. Nutadhira.

Remarks: The whorl of the present specimen is more compressed (width index 22.5 %) than the 41.8–58.3 % of the specimens in Gordon (1964, pl. 20, Figs. 28–44, Figs. 50A, G, 51B).

Suborder Ceratitina Hyatt, 1884.

Family Ophiceratidae Arthaber, 1911.

Genus *Ophiceras* Griesbach, 1880.

Type species: *Ophiceras tibeticum* Griesbach, 1880.

Ophiceras connectens Schindewolf, 1954
(Fig. 3c–e)

1970. *Ophiceras connectens*; Kummel, pl. 1, Figs. 2–9, p. 187.

Material: One specimen (PRC-SHM-KO-138), diameter 19.8 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu,

Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: The suture of the present specimen is feebly concave but Kummel (1970; Fig. 2, B) reported specimens, which had a third truncate lateral lobe that gradually tilted up to the umbilicus wall.

Family Flemingitidae Hyatt, 1900.

Genus: *Xenodiscoides* Spath, 1930.

Type species: *Xenodiscus perplicatus* Frech, 1905.

Xenodiscoides perplicatus (Frech 1905)

(Fig. 3f–h)

1957. *Xenodiscoides perplicatus*; Arkell et al., Fig. 169, 2, p. L137.

Material: Two specimens (PRC-SHM-KO-060, PRC-92), diameter 24.7 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: Four ribs on the outer whorl near the aperture of the present specimen were thicker than the other ribs and were expanded on the middle of the flank. Such features are absent in the specimen figured by Arkell et al. (1957; Fig. 169, 2, p. L137).

Family Meekoceratidae Waagen, 1895.

Genus *Juvenites* Smith, 1927.

Type species: *Juvenites krafftii* Smith, 1927.

Juvenites canadensis (Tozer 1961)

(Fig. 3i, j)

1961 *Juvenites canadensis*; Tozer, pl. 8, no. 3a–d.

1994 *Artautocelites (Thermalites) canadensis*; Tozer, pl. 21, Fig. 1a, b, p. 391.

Material: Five specimens (PRC-SHM-KO-081, 375; PSUNHM-2297-505-002, 155, 156), dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Family: Paranannitidae Spath, 1930.

Genus *Arianites* Arthaber, 1911.

Type species: *Arianites musacchi* Arthaber, 1911.

Arianites musacchi Arthaber, 1911

(Fig. 3k, l)

1968 *Arianites musacchi*; Kummel, pl. 2, Figs. 9–10, text-Fig. 26.

1957 *Arianites musacchi*; Arkell et al., Figure 172 (14a, b), p. L141.

Material: Seven specimens (PRC-SHM-KO-016, 207, 220, 289, 370, 389, 419), diameter 3.7–6.7 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: The present specimens are juveniles. Small nodes along the median flank, that were absent in the adult (Kummel 1968; pl. 2, Figs. 9, 10, text-Fig. 26) are visible in the present material.

Genus *Epiceltites* Arthaber, 1911.

Type species: *Epiceltites genfii* Arthaber, 1911.

Epiceltites genfii Arthaber, 1911

(Fig. 3m, n)

1968 *Epiceltites genfii*; Kummel, pl. 3, Figs. 10, 11, p. 565; pl. 35, Figs. 6, 7, p. 629; text-Fig. 26L, p. 442.

2003 *Epiceltites genfii*; Mertmann and Jacobshagen, pl. 2, Fig. 14, p. 441; Fig. 23, p. 430.

Material: Two specimens (PRC-SHM-KO-061, PRC-91), diameter 21.4–25.2 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Family Ussuridae Spath, 1930.

Genus *Ussuria* Diener, 1895.

Type species: *Ussuria schamarai* Diener, 1895.

Ussuria sp. A

(Fig. 4a–c)

Material: 4 specimens (PRC-SHM-KO-020, 083, 314; PSUNHM-2297-505-040), diameter 5.3–10.1 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: Three lateral saddles present in the available specimens compared to only two in other species of the genus. Lobes and saddles are serrated in other species of the genus but smooth in present specimens.

Ussuria sp. indet.

(Figure 4d–e)

Material: 198 specimens (PRC-SHM-KO-018 to 672), diameter 3.5–12.4 mm, dolomite rock, Phukhaothong

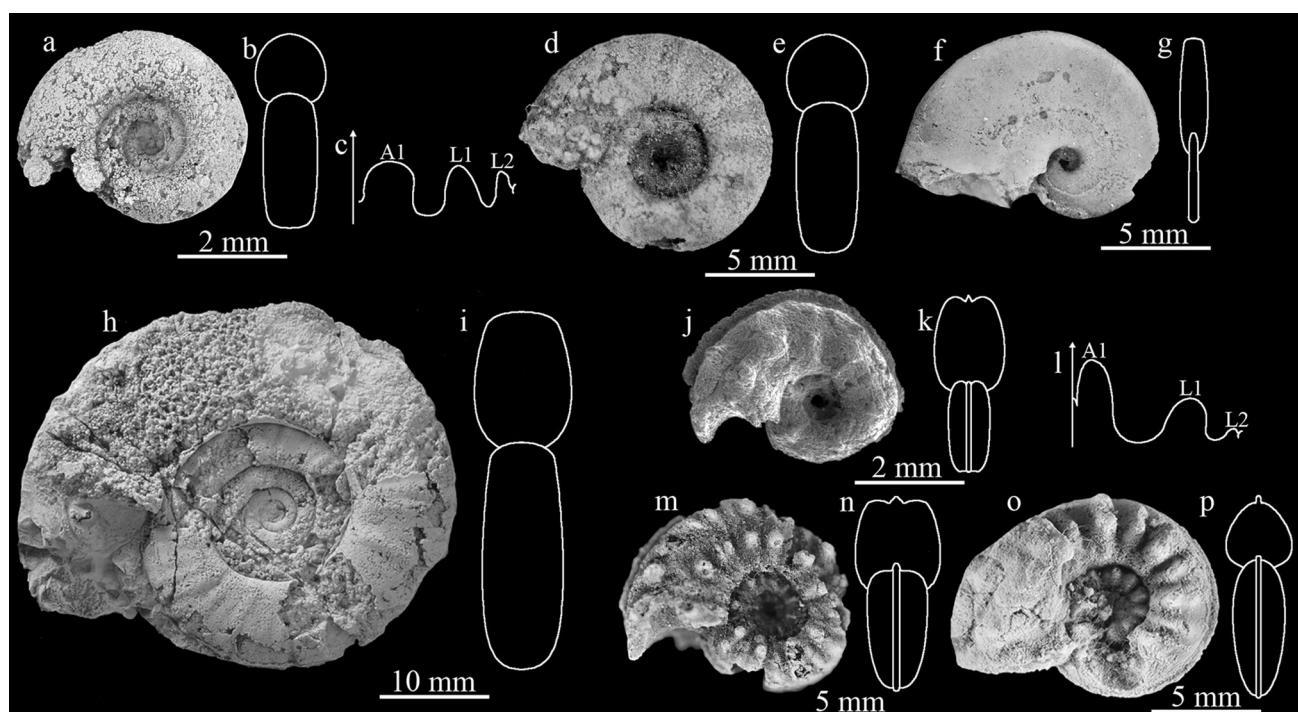


Fig. 4 a–c *Ussuria* sp. A; PRC-SHM-KO-020, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, a lateral view, b cross section, c ceratitic suture; d, e *Ussuria* sp. indet.; PRC-SHM-KO-272, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, d lateral view, e cross section; f, g *Bosnites clathratus* Hyatt and Smith, 1879; PRC-SHM-KO-035, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, f lateral view, g cross section; h, i *Paracrochordiceras* sp. indet.; PRC-SHM-KO-054, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, h lateral view, i cross

section; j–l *Kellnerites bosnensis* (Hauer, 1888); PRC-SHM-KO-022, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, j lateral view of juvenile, k cross section, l ceratitic suture; m, n *Halilucites* sp. A; PRC-SHM-KO-376, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, m lateral view, n cross section; o, p *Halilucites* sp. B; PSUNHM-2197-505-012, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, m lateral view, n cross section

Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: Overall characteristics resemble *Ussuria* sp. A, but sutures are not visible.

Family Noritidae Karpinsky, 1889.

Genus *Bosnites* Hauer, 1896.

Type species: *Bosnites clathratus* Hauer, 1897.

Bosnites clathratus Hauer, 1897

(Fig. 4f, g)

1957 *Bosnites clathratus*; Arkell et al., Figure 176, 4a, b, p. L146.

Material: Two specimens (PRC-SHM-KO-035, 326), diameter 10.1–17.2 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Family Acrochordiceratidae Arthaber, 1911.

Genus *Paracrochordiceras* Spath, 1934.

Type species: *Acrochordiceras anodosum* Welter, 1915.

Paracrochordiceras sp. indet.

(Figure 4h–i)

Material: Five specimens (PRC-SHM-KO-054, 095, 330; PSUNHM-2297-505-157,158), dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Family Ceratitidae Mojsisovics, 1879.

Genus *Kellnerites* Arthaber, 1912.

Type species: *Ceratites bosnensis* Hauer, 1887.

Kellnerites bosnensis (Hauer 1888)

(Fig. 4j–l)

1957 *Kellnerites bosnensis*; Arkell et al., Figure 183, 1, p. L151.

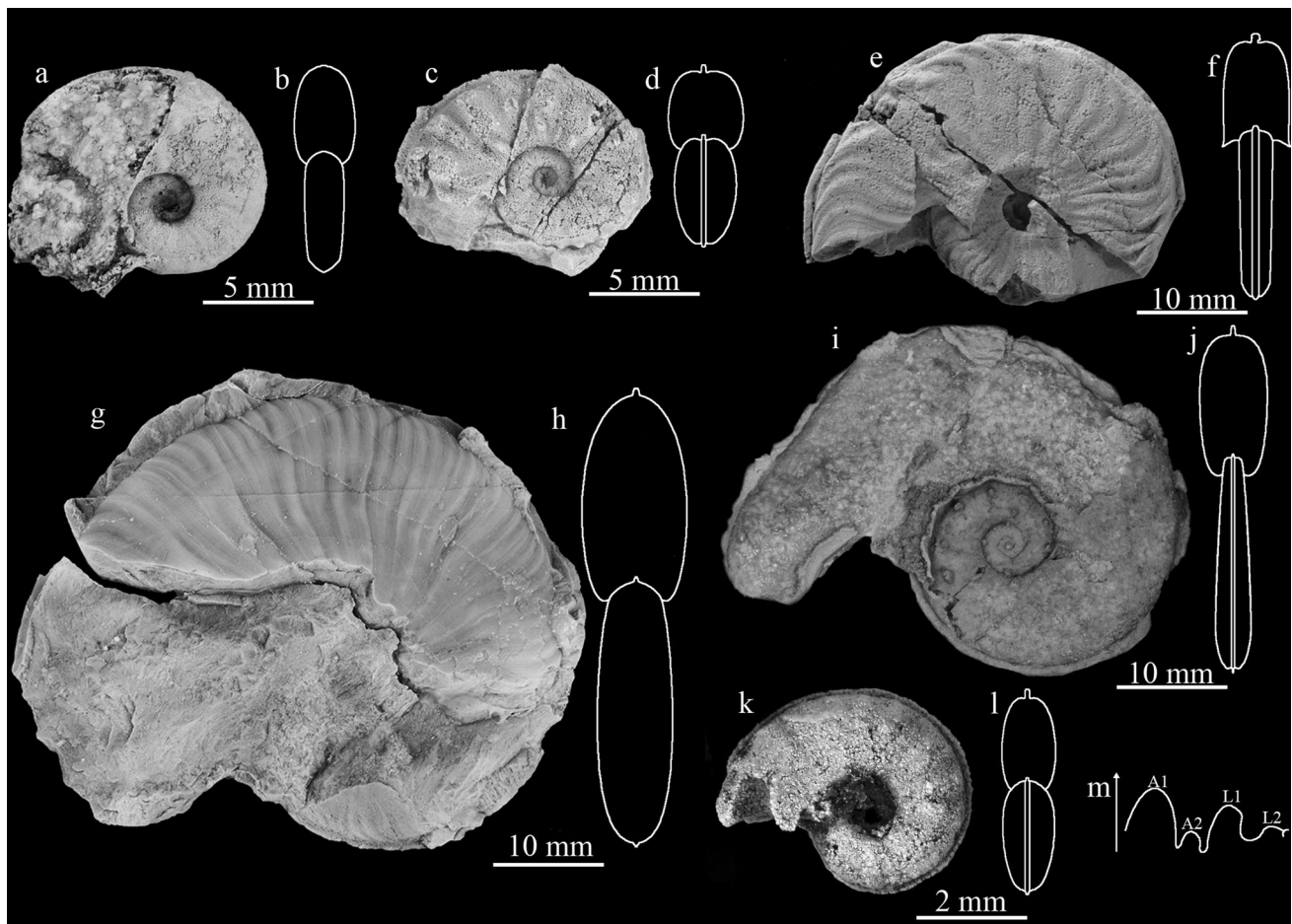


Fig. 5 a–b *Eutomoceras* aff. *laubei* Meek, 1877; PRC-SHM-KO-322, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, a lateral view, b cross section; c, d *Eutomoceras dunni* Smith, 1904; PRC-SHM-KO-147, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, c lateral view, d cross section; e, f *Eutomoceras* sp. A; PRC-134, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, e lateral view, f cross section, sulcus on keel basement; g, h *Eutomoceras* sp. B; PRC-SHM-KO-

053, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, g lateral view, h cross section; i, j *Eutomoceras* sp. C; PRC-SHM-KO-108, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, i lateral view, j cross section; k–m *Eutomoceras* sp. D; PRC-SHM-KO-486, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, k lateral view, l cross section, m ceratitic suture

1964 *Kellnerite* cf. *bosnensis*; Bando, pl. 5, Fig. 6, p. 147. 1993 *Kellnerites bosnensis*; Brack & Rieber, pl. 5, Figs. 7–10, 13–14, p. 509.

Material: Three adult specimens (PRC-SHM-KO-131, 156, 296) and 17 juveniles (PRC-SHM-KO-022, 101, 148-1, 148-2, 148-7, 148-8, 194, 353, 358, 369, 414, 417, 459, 628, 633, 634; PSUNHM-2297-505-152), diameter 19.8–31.8 mm in adult and 3.7–13.3 mm in juvenile, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: The ribs of the adult *K. bosnensis* in Bando (1964; pl. 5, Fig. 6, p. 147) are branched and had three tubercles, but only two in the present “juvenile” specimens. The keel is blunt in all the present specimens.

Genus *Halilucites* Diener, 1905.

Type species: *Ceratites rusticus* Hauer, 1896.

Halilucites sp. A
(Fig. 4m–n)

Material: 24 specimens (PRC-SHM-KO-084, 295, 329, 337, 356, 376, 382, 387, 395, 470, 506; PSUNHM-2297-505-001, 002, 004–014, 153, 154), diameter 5.2–17.3 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: The ribs are falcoid with two nodes on the flanks of the present specimens, but they are falcate without nodes in other species of the genus.

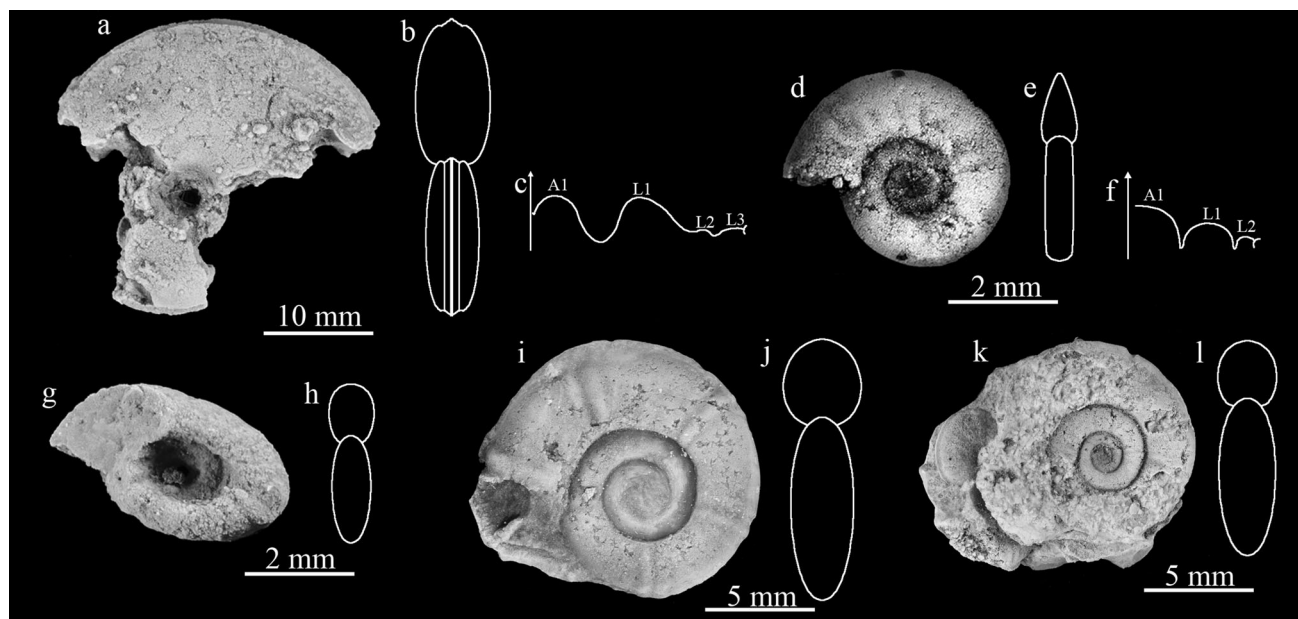


Fig. 6 a–c *Hungarites* sp. A; PRC-SHM-KO-078, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, a lateral view, b cross section, c ceratitic suture; d–f *Aplococeras parrus* (Smith, 1914); PRC-SHM-KO-027, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, d lateral view, e cross section, f ceratitic suture; g, h *Indoceltites trigonalis* (Diener, 1908); PRC-SHM-KO-264, Chaiburi Formation, Triassic,

7°37'N, 100°5'E, g lateral view, h cross section.; i, j *Audaxlytoceras audax* Meneghini, 1881; PRC-SHM-KO-048, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, i lateral view, j cross section; k, l *Protetragonites* sp. A; PRC-87, Chaiburi Formation, Triassic, 7°37'N, 100°5'E, k lateral view, l cross section

Halilucites sp. B (Fig. 4o–p)

Material: Two specimens (PRC-SHM-KO-084, 395), diameter 6.8–17.3 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: Falcoid ribs of the present specimens differ from falcate ones of other species of the genus. Absence of nodes is a similar characteristic to other species of the genus, but ribs are concave, pronounced.

Genus *Eutomoceras* Hyatt, 1877.

Type species: *Eutomoceras laubei* Meek, 1877.

Eutomoceras aff. *laubei* Meek, 1877 (Fig. 5a, b)

1914 *Eutomoceras laubei*; Smith, pl. 10, Figs. 7–11, p. 160, pl. 14, Fig. 8–8a, pl. 24, Figs. 7–9, p. 174, pl. 27, Figs. 1–13, p. 177, pl. 90, Figs. 1–4, p. 238.

Material: 1 specimen (PRC-SHM-KO-322), diameter 13.0 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: The external morphology of the present specimen is similar to *E. laubei* Meek, 1877 (Smith 1914; pl. 27, Figs. 5–10, p. 177), except for the presence for the bituberculation on the apertural zone of the third whorl.

Eutomoceras dunni Smith, 1904 (Fig. 5c–d)

1914 *Eutomoceras dunni*; Smith, pl. 27, Figs. 14–25, p. 177.

1982 *Eutomoceras dunni*; Silberling and Nichols, pl. 18, Figs. 8–15, p. 116.

2007 *Eutomoceras dunni*; Jenks et al., pl. 24, figs. C–D, p. 63.

Material: 1 specimen (PRC-SHM-KO-147), diameter 14.3 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Eutomoceras sp. A (Fig. 5e–f)

Material: 1 specimen (PRC 134), diameter 32.8 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: The presence of a sulcus on the left side at the keel in the present specimen has never been mentioned from other species of the genus.

Eutomoceras sp. B
(Fig. 5g, h)

Material: Two specimens (PRC-SHM-KO-053, 139), diameter 14.1–55.4 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: The presence of branched ribs and the alternating arrangement of the branch and branchless ribs are absent from other species of the genus but pronounced in the present specimens.

Eutomoceras sp. C
(Fig. 5i–j)

Material: Three specimens (PRC-SHM-KO-108, 128, 129), diameter 21.2–41.9 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: The hexagonal umbilicus is the unique characteristics of the present specimens, and differs from the round umbilicus in other species of the genus.

Eutomoceras sp. D
(Fig. 5k–m)

Material: 103 specimens (PRC-SHM-KO-025 to 647; PSUNHM-2297-505-015, 027–039), diameter 3.6–38.0 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: Two of the lateral saddles are larger than the others in the present specimens, compared to subequal ones in other species of the genus.

Family Hungaritidae Waagen, 1895.
Genus *Hungarites* Mojsisovics, 1879.
Type species: *Ceratites mojsisovicsi* Roth, 1871.

Hungarites sp. A
(Fig. 6a, b)

Material: Eight specimens (PRC-SHM-KO-078, 080, 106, 107, 118, 629, 630, 631), diameter 15.33–23.10 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi

Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: The lobes of the suture line are serrated in *H. yatesi* (Hyatt and Smith 1905, pl. 20, Figs. 1–4, 257 p.), but the lobes are smooth in the present specimens. Other characteristics resemble *H. yatesi*.

Family Aplococeratidae Spath, 1951.
Genus *Aplococeras* Hyatt, 1900.
Type species: *Dinarites avisianus* Mojsisovics, 1882.

Aplococeras parvus (Smith 1914)
(Fig. 6d–f)

1982 *Aplococeras parvus*; Silberling and Nichols, pl. 22, Figs. 18–23; text-Fig. 38, p. 53.

Material: 387 specimens (PRC-SHM-KO-021 to 668; PSUNHM-2297-505-003 to 151), diameter 3.1–13.9 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: The overall shell shape and septal suture line elements of present specimens are similar to *A. parvus* (Silberling and Nichols 1982, pl. 22, Figs. 18–23; text-Fig. 38, p. 53), but the 1st lateral saddle is smaller than the ventral one, that is equal in the type specimen.

Family Celtitidae Mojsisovics, 1893.
Genus *Indoceltites* Diener, 1919.
Type species: *Celtites perauritus* Diener, 1908.

Indoceltites trigonalis (Diener 1908)
(Fig. 6g, h)

1957 *Indoceltites trigonalis*; Arkell et al., Fig. 202, 2, p. L172.

Material: 14 specimens (PRC-SHM-KO-090, 264, 346, 349, 635 to 644), diameter 4.3–8.9 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Suborder Lytoceratina Hyatt, 1889.
Family Nannolytoceratidae Spath, 1927.
Genus *Audaxlytoceras* Fucini, 1923.
Type species: *Lytoceras audax* Meneghini, 1881).

Audaxlytoceras audax Meneghini, 1881
(Fig. 6i–j)

1957 *Audaxlytoceras audax*; Arkell et al., Fig. 228, 1, p. L199.

1995 *Audaxlytoceras audax*; Alkaya and Meister, pl. IV, Fig. 3, p. 171.

1998 *Audaxlytoceras audax*; Lachkar et al., Fig. 5. 7–8, p. 597.

Material: Four specimens (PRC-SHM-KO-048,143, PRC-89, 90), diameter 15.2–21.3 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: The characteristics of the present specimens corresponded to *A. audax* (Arkell et al. 1957: Fig. 228, 1a–c, L 199), but the whorl section is more compressed.

Family Protetragonitidae Spath, 1927.

Genus *Protetragonites* Hyatt, 1900.

Type of species: *Ammonites quadrisulcatus* (D'orbigny, 1841).

Protetragonites sp. A

(Fig. 6k, l)

Material: Two specimens (PRC-87, 88), diameter 16.6–20.0 mm, dolomite rock, Phukhaothong Dolomite Member, Chaiburi Formation, Triassic, Khao Ok-Thalu, Changwat Phatthalung, 7°37'N, 100°5'E, collector P. Srisuk.

Remarks: The overall characteristics of the present specimens are similar to *P. crebrisulcatus*. The latter species has dense ribs on the inner and outer whorls (Nagy 1967; pl. 3, fig. 2, p. 76, pl. 4, Fig. 3, p. 77), but those ribs are absent in the present specimens.

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