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Late Jurassic to Early Cretaceous ammonite fauna from the Somanakamura Group in Northeast Japan

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Abstract. Over 300 specimens of ammonites of Late Jurassic to Early Cretaceous age were collected by the members of local fossil research associations from various localities in the Soma area, Northeast Japan. The new collection of ammonites is confined to two formations, Nakanosawa Formation in the lower and Koyamada Formation in the upper part of the Somanakamura Group. Four ammonite-bearing levels (A2 to A5) are ascertained in these formations, and each level was dated by the ammonites discovered. The lower three levels (A2, A3 and A4) are contained in the Nakanosawa Formation. The newly collected ammonites from this formation include a well preserved adult specimen of *Aulacosphinctoides tairai* sp. nov., relatively well preserved specimens of *Subdichotomoceras chisatoi* sp. nov., hitherto unknown *Haploceras* sp. and *Hybonoticeras* sp., besides many already known species. The lowest level A2 represents a certain age within the Kimmeridgian - early Tithonian. The next lower, A3, somewhat later than the former, is correlated to the late Kimmeridgian to early Tithonian, and the upper level, A4, to the Tithonian. The Nakanosawa fauna indicates therefore the Kimmeridgian to Tithonian interval as a whole. The ammonites from the Koyamada Formation, known only from the uppermost level A5, include a new species of *Dalmasiceras muneoi*, besides other berriasellids and neocomitids. The age of the formation is Berriasian. The ages hitherto assigned are not greatly modified by the new discoveries. Descriptions of the new species and some other interesting species are given in this paper.

Key words: Late Jurassic, Early Cretaceous, new species, ammonites, Somanakamura Group, Northeast Japan

Introduction

The Somanakamura Group (renamed by Mori, 1963, called Soma Group before) is composed of basically detrital sediments, with subordinate bituminous limestone lenses at its upper part. It represents a series of continental shelf sediments and river or lake deposits, accumulated on the Pacific coast of the pre-Jurassic Abukuma Mountains in the Middle Jurassic to Early Cretaceous. A stratigraphical classification was first proposed by Tokunaga and Otsuka (1930) and later elaborated by Masatani (1950), whose formational classification has been basically retained until now though a few modifications were proposed later. The most recent stratigraphical summary of the group was given by Fujita *et al.* (1988), Kubo *et al.* (1990) and Yanagisawa *et al.* (1996), and its geographical distribution is shown on the geological sheet maps of Kakuda, Somanakamura, and Haramachi and Omika, at the scale of 1:50,000, published by the Geological Survey of Japan.

Occurrences of ammonites in the group have been reported since the 1920s, but few were described systematically and figured. Many names were only cited in the course of stratigraphical description. The age assignment of the group was made by these ammonites and pelecypods with subordinate plants and corals as discussed, for instance, by Masatani and Tamura (1959).

Recently a large number of ammonites were collected by the members of the Iwaki Natural History Research Association and the Somanakamura Group Research Association, both nonprofessional fossil lovers' clubs. The new collections, more than 300 in number, were temporarily gathered in the Fukushima Museum at Aizuwakamatsu City for paleontological study, and the authors had the privilege of studying them thoroughly. The collections include well preserved specimens of new and hitherto unknown species. As a result it became clear that the Somanakamura Group has an unexpectedly

rich ammonite fauna contrary to the general perception up to now. The newly collected ammonites were already briefly outlined by Sato *et al.* (2005). In this paper, new and hitherto little known species are described systematically, and chronological and paleobiogeographical discussions are presented.

Geological setting

The Somanakamura Group is distributed along the eastern margin of the Abukuma Mountains, Northeast Japan (Figure 1). It is exposed in a north-south directed narrow belt, about 27 km in length and 3–4 km in width. A simplified geological map of the group is shown in Figure 2. This group is in fault contact with the Cretaceous granitic rocks and Neogene deposits in its western margin by the Futaba fault, and is covered unconformably with the Neogene in the eastern margin. The group is broadly folded to form an anticline as a whole with an axis running in the north-south direction, and the stratigraphy can be established with certainty. The group is divided into six formations; Awazu, Yamagami (or Sugaya), Tochikubo, Nakanosawa, Tomizawa and Koyamada formations in ascending order (Figure 3). Detailed discussion of the ages will be given later.

Awazu Formation (Masatani, 1950): This formation is exposed in a small area in the northern part of the main distribution area of the group. Its thickness is about 280 m (Yanagisawa *et al.*, 1996). The formation is mainly composed of black sandy shale of an offshore environment. Some ammonites and pelecypods are obtained from this formation (Masatani, 1950; Sato, 1962; Masatani and Tamura, 1959). The Awazu Formation is broadly correlated to Bajocian to Bathonian (Middle Jurassic) based on ammonites (Sato, 1962).

Yamagami Formation (Mori, 1963) = Sugaya Sandstone of Masatani (1950): This formation is exposed in a narrow area of the northern part of the group, conformably covering the Awazu Formation. Its thickness is about 250 m (Yanagisawa *et al.*, 1996). The formation constitutes of shallow marine deposits, mainly composed of stratified sandstone. Many pelecypods were reported from the formation by Masatani (1950) and Masatani and Tamura (1959). The formation is preliminarily dated Callovian, interpolated from the ages of the underlying and overlying formations.

Tochikubo Formation (Masatani, 1950): This formation is very widely exposed in the central belt of the main distribution area of the group, along the anticlinal axis of the group. Its thickness is about 500 m according to Masatani (1950) or 350 m according to Mori (1963). The formation is composed mainly of fine sandstone-shale alternation and stratified medium to fine sandstone, containing massive coarse sandstone layers. The sedimentary environment gradually changes from fluvial to lacustrine and finally to deltaic. Abundant plant fos-

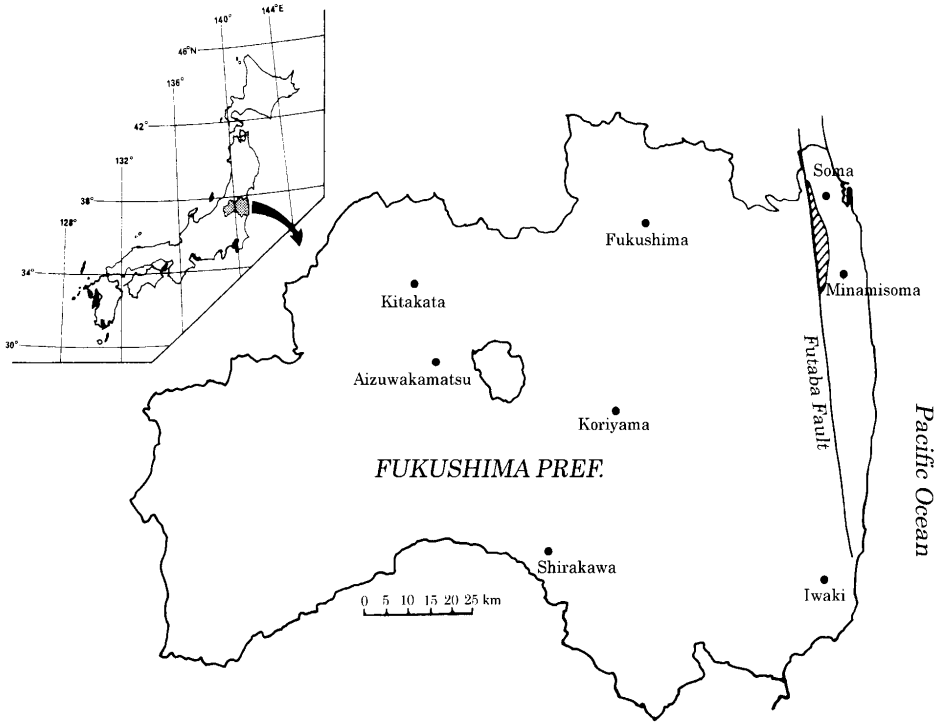


Figure 1. Distribution of the Somanakamura Group (shaded area). Modified from Sato *et al.* (2005).

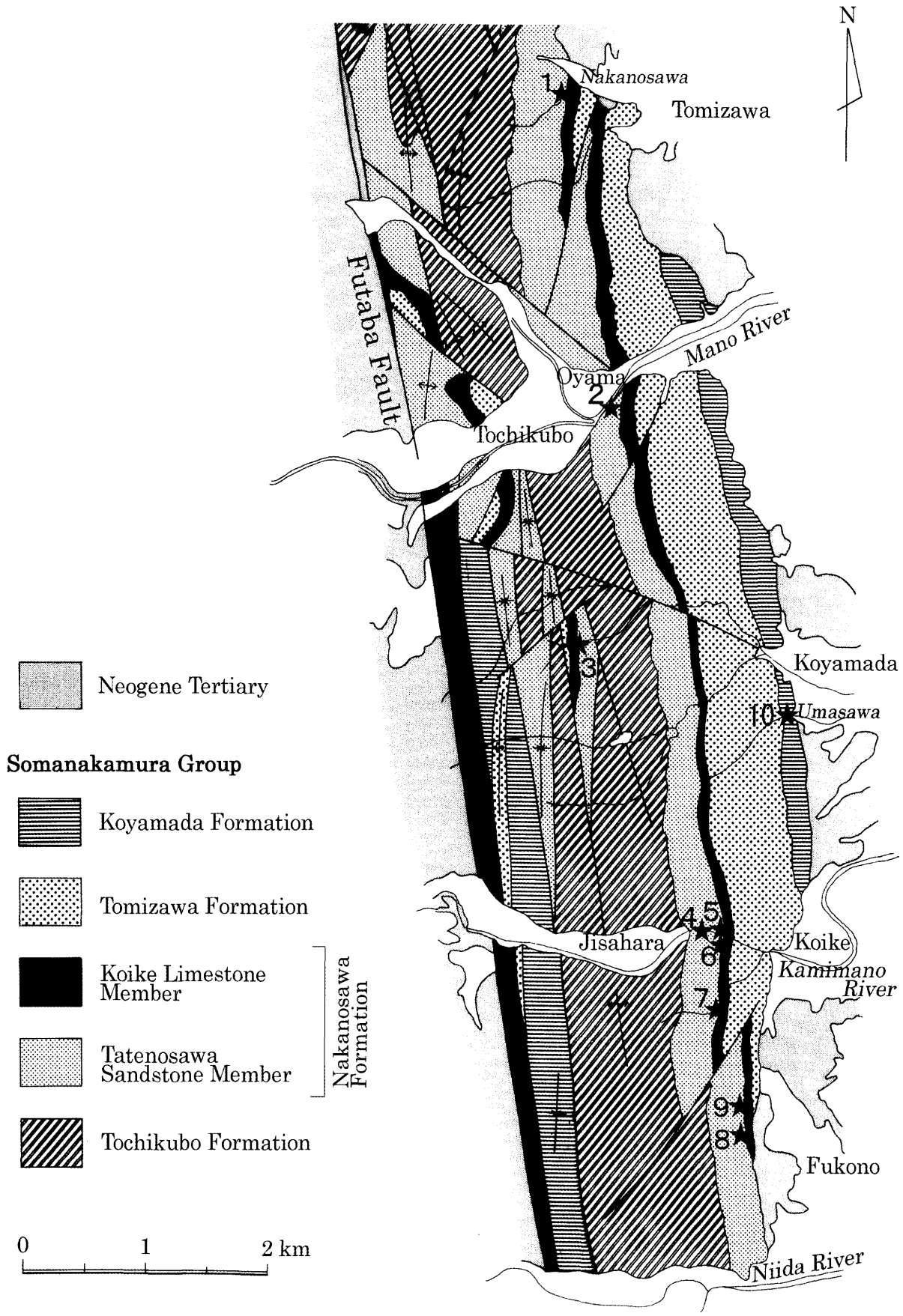


Figure 2. Geological map of the Somanakamura Group (modified from Yanagisawa *et al.*, 1996) indicating the ammonite localities.

PERIOD	EPOCH	AGE	Ma	FORMATION
Cretaceous	Early	Valanginian	140.2	Koyamada F.
		Berriasian	145.5	
Jurassic	Late	Tithonian	150.8	Tomizawa F.
		Kimmeridgian	155.7	Nakanosawa F.
		Oxfordian	161.2	Tochikubo F.
	Middle	Callovian	164.7	Yamagami F.
		Bathonian	167.7	Awazu F.
		Bajocian		

Figure 3. Sequence and geological age of the Somanakamura Group. The age value is based on Gradstein *et al.* (2004).

sils are collected from several horizons in the formation. The flora is of the Ryoseki type (Kimura and Ohana, 1988a, b). The age of this formation is judged to be Oxfordian based on the age of the underlying and overlying formations.

Nakanosawa Formation (Tokunaga and Otsuka, 1930; emend. Masatani, 1950): This formation is exposed in two rows, on both wings of the anticline of the group. It overlies the Tochikubo Formation conformably. Its thickness is about 160 m according to Masatani (1950) or 230 m according to Kubo *et al.* (1990). The formation is divided into the lower Tatenosawa Sandstone Member (Yanagisawa *et al.*, 1996) and the upper Koike Limestone Member (Masatani, 1950). The Tatenosawa Sandstone Member is mainly composed of coarse sandstone, intercalating fine to medium sandstone beds, of shallow marine origin. In its uppermost part, muddy and calcareous (marly) sandstone beds become dominant and gradually merge to the Koike Limestone Member. The latter member is composed of dark gray impure limestone with marl intercalations. The Nakanosawa Formation is very fossiliferous, as reported by various authors until now (marine fossils are by Shimizu, 1928, 1930, 1931; Masatani, 1950; Tamura, 1959; Masatani and Tamura, 1959; Sato, 1962; Mori, 1963; and others). From the Tatenosawa Sandstone Member, some reptiles and fish teeth and scales are discovered besides many invertebrate fossils. The Koike Limestone Member contains various fossils, such as corals, calcareous algae, stromatoporoids, echinoids, brachiopods, gastropods, pelecypods and ammonites. The contents of the fauna and the lithofacies of the member resemble remarkably those of the Torinosu Limestone of late Jurassic age, which is discontinuously distributed in the Outer Belt of Southwest Japan all along the Pacific coast. Sato (1962) recognized three ammonite-bearing levels (A2, A3 and A4) in this formation, which are retained in this paper. This formation was correlated to the Kimmeridgian and Tithonian as a whole based on the contained ammonites.

Tomizawa Formation (Tokunaga and Otsuka, 1930; emend. Masatani, 1950; Masatani and Tamura, 1959): This formation is mainly distributed on the eastern wing of the anticline of the group. It covers the Nakanosawa Formation conformably. Its thickness is about 400 m (Yanagisawa *et al.*, 1996). The formation is composed mainly of coarse sandstone. Very coarse to coarse sandstone is dominant in the lower part, sometimes conglomeratic. Massive shale beds are intercalated in coarse sandstone beds in the upper part. Some plant fossils are discovered. These are fluvial and flood plain deposits resulting from rapid upheaval and erosion of the hinterland. The age was attributed to the Tithonian, judged by the ages of the underlying and overlying formations.

Koyamada Formation (Masatani, 1950): This formation is exposed discontinuously on the western and eastern marginal parts of the main distribution area of the group. It is covered by the Neogene with an unconformity on the eastern border. The thickness is about 150 m (Yanagisawa *et al.*, 1996). The underlying Tomizawa Formation gradually merges to this formation. The Koyamada formation is mainly composed of shale and fine sandstone, often intercalated with tuff, tuffaceous sandstone and siliceous shale. Marine fossils such as pelecypods, ammonites and radiolarians (Masatani, 1950; Tamura, 1959; Masatani and Tamura, 1959; Sato, 1961a, b; Matsuoka, 1989) are reported abundantly from this formation. The facies of the formation is offshore marine. An abrupt transgression took place after the sedimentation of the Tomizawa Formation, judged by the change of the facies of both formations. The age of the formation is Berriasian to probably Valanginian, on the basis of the fossils it contains such as ammonites and radiolarians.

Ammonite-bearing levels

Ammonites occur only in the following five stratigraphic levels which were described as "niveaux" by Sato (1962). No new levels were so far discovered even after the new collection. In ascending order;

Level A1 in the Awazu Formation: only one ammonite species, *Bigotites* sp., is known up to now (Sato, 1962).

Level A2 in the lower part of the Tatenosawa Sandstone Member of the Nakanosawa Formation (*Lima* sandstone member by Masatani, 1950): many ammonites were cited in Masatanai (1950), but not described or figured (see list of ammonites hitherto described or

recorded given below).

Level A3 in the calcareous sandstone beds of the uppermost part of the Tatenosawa Sandstone Member of the Nakanosawa Formation (Middle coarse sandstone member by Masatani, 1950): numerous ammonites including *Taramelliceras* sp., *Aulacosphinctoides* cf. *steigeri*, *Aspidoceras* occur in this level, but the identifications of many other ammonites remain doubtful.

Level A4 in the Koike Limestone Member of the Nakanosawa Formation: *Aulacosphinctoides* cf. *steigeri* (Shimizu) occurs in this level in association with oppeliids and perisphinctids. Sato and Westermann (1991) recognized an ammonite association composed of these forms and correlated it to the lower Tithonian.

Level A5 in the Koyamada Formation: *Perisphinctes* (*Paraboliceras*?) *japonicus* and other perisphinctid ammonites were recorded (Yabe, 1943; Masatani, 1950), and later *Parakilianella umazawensis*, *Thurmanniceras* sp. and *Berriasella* sp. were added by Sato (1961a, b). This assemblage indicates a Berriasian age.

Localities of ammonite findings

The new findings of the ammonites were made from almost all over the distribution area of the Somanakamura Group, but many of them are unfortunately not precisely controlled stratigraphically. Of these sample sites, ten localities provided important collections. They are shown in Figure 2 and the stratigraphical columns of the sites are shown in Figure 4.

Locality 1: A limestone quarry at Tomizawa, Soma City (Locality (1) in Sato *et al.*, 2005). Whole section of the Nakanosawa Formation is well exposed along the Nakanosawa River including this locality. A number of ammonite specimens are collected from the calcareous nodules included in the calcareous sandstone bed of the uppermost Tatenosawa Sandstone Member, just below the Koike Limestone. This locality represents the level A3 mentioned above. A paratype of *Aulacophinctoides tairai* sp. nov. (MM coll. cat. no. 000049-49-186-002) was discovered from this locality.

Locality 2: Right bank of the Mano River to the south of Oyama, Kashima-ku, Minamisoma City (Locality (3) in Sato *et al.*, 2005). An almost complete section of the Nakanosawa Formation is exposed here. Ammonites are discovered from the muddy sandstone bed in the middle part of the Tatenosawa Sandstone Member. This level corresponds to level A2. The holotype of *Subdichotomoceras chisatoi* sp. nov. (FM coll. cat. no. N200500627) was discovered from this locality.

Locality 3: Kabesu Forestry Road in Koyamada, Kashima-ku, Minamisoma City (Locality (5) in Sato *et al.*, 2005). A small fraction of the Nakanosawa Formation including the Koike Limestone and its subjacent detrital sediments is exposed here. Ammonites are found in the nodule-bearing calcareous fine-grained sandstone bed and the overlying limestone. This locality represents the levels A3 and A4.

Locality 4: 50 m upstream from the Tachimi-ishi Bridge of the Kamimano River, Jisahara, Kashima-ku, Minamisoma City (Locality (6) in Sato *et al.*, 2005). A rather continuous section of the middle part of the Nakanosawa Formation is exposed here. Ammonites, though fragmentary, are collected from the calcareous sandstone bed of the middle part of the Tatenosawa Sandstone Member . This corresponds to level A2.

Locality 5: North side cliff of the Kamimano River, Koike, Kashima-ku, Minamisoma City, downstream of Locality 4 (Locality (6) in Sato *et al.*, 2005). The upper part of the Nakanosawa Formation is well exposed here. The famous huge exposure of the "Koike Limestone" is included. Two horizons particularly rich in ammonites are discernible; the lower in the calcareous sandstone bed of the uppermost Tatenosawa Sandstone Member (level A3) and the upper in the marly sandstone bed intercalated in the lower part of the Koike Limestone Member (level A4). The holotype of *Aulacosphinctoides tairai* (KHFM coll. cat. no. 220001) and a tiny but well preserved specimen of *Haploceras* sp. were discovered in the lower level.

Locality 6: South side slope of the Kamimano River, Koike, Kashima-ku, Minamisoma City (Locality (6) in Sato *et al.*, 2005), opposite to the Locality 5. The Nakanosawa Formation, including the Koike Limestone, is exposed here. Many ammonites were collected from a small exposure. The locality includes the levels A3 and A4.

Locality 7: Tatenosawa Forestry Road in Koike, Kashima-ku, Minamisoma City. The Nakanosawa Formation is continuously exposed along the road (Locality (7) in Sato *et al.*, 2005). Ammonites occur at the topmost part of the member, just below the Koike Limestone. Many ammonites are discovered from this locality, such as *Aulacosphinctoides*, *Subdichotomoceras*, *Pachysphinctes*, *Haploceras*, *Ochetoceras*, *Taramelliceras*, *Hybonoticeras* and so on. This level corresponds to level A3.

Locality 8: Fukono-Nakayama Forestry Road in Fukono, Haramachi-ku, Minamisoma City (Locality (8) in Sato *et al.*, 2005). Ammonites occur in the marly sandstone in the uppermost part of the Tatenosawa Sandstone Member, just below the Koike Limestone. A microconch of *Subdichotomoceras chisatoi* sp. nov. (KHFM coll. cat. no. 220017) was collected from this locality. This horizon corresponds to level A3.

Locality 9: A valley north of the Fukono-Nakayama

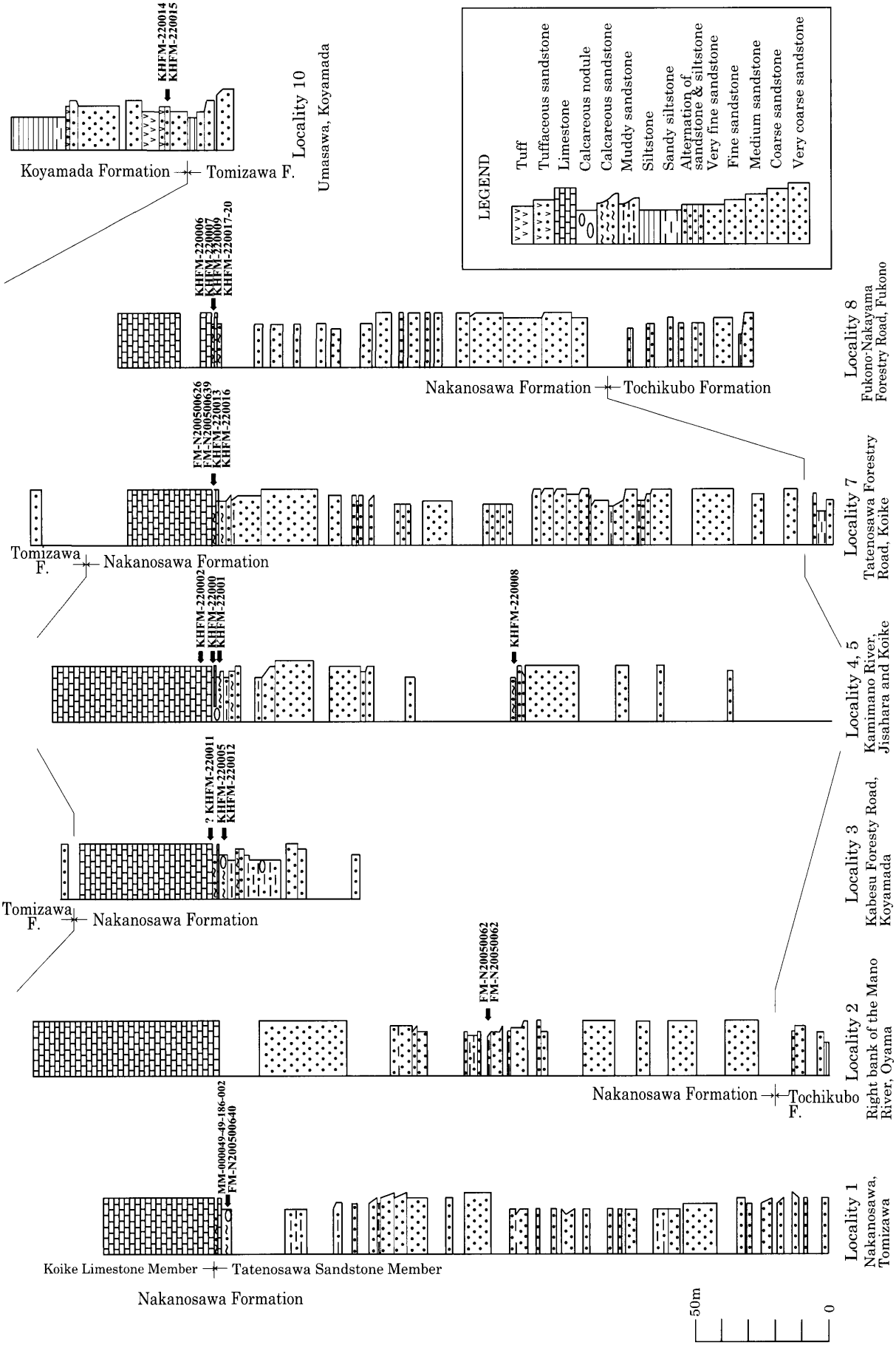


Figure 4. Columnar sections along the investigated routes and the ammonite-bearing horizons. Columnar sections of localities 6 and 9 are not shown because rock exposures at the localities are sporadic.

Forestry Road, Fukono, Haramachi-ku, Minamisoma City (Locality (8) in Sato *et al.*, 2005). Marly sandstone beds of the Tatenosawa Sandstone Member and the Koike Limestone rocks are exposed at this locality. Many ammonites were discovered from the marly sandstone. This belongs to level A3.

Locality 10: Umasawa in Koyamada, Kashima-ku, Minamisoma City (Locality (9) in Sato *et al.*, 2005). The Koyamada Formation is well exposed here. Ammonites occur in fine-grained sandstone of the lower part of the Koyamada Formation. Ammonite specimens are abundantly collected from this bed. The bed is overlain by the characteristic tuff beds. The holotype of *Dalmasiceras muneoi* sp. nov. (KHFM coll. cat. no. 20014) was collected from this locality. This locality corresponds to level A5.

List of the ammonites hitherto described or recorded from the Somanakamura Group

The new collection enriched greatly the ammonite fauna of the Somanakamura Group, which has thus far been considered to be rather poor in number and quality. The list of the hitherto reported species is given below. A species name accompanied by an asterisk * means that the species was identified in the stratigraphical descriptions but not described or illustrated. Species with two asterisks ** are described herein.

Awazu Formation: level A1

Bigotites sp. (Sato, 1962, p. 35, pl. 10, figs. 9, 11) = **Parkinsonia* sp. (Masatani, 1950, p. 499, 503; Masatani and Tamura, 1959, p. 256) =**Bigotites* (Mori, 1963, p. 9) =**Bigotites* sp. (Yanagisawa *et al.*, 1996, p. 37).

Nakanosawa Formation: *Lima* sandstone member, level A2

Taramelliceras sp. including *T.* sp. cf. *T. callicerum* (Oppel) (Sato, 1962, p. 35, pl. 10, fig.2; Sato *et al.*, 2005, p. 20) =**Neumayriceras* cf. *callicerum* Oppel (Masatani, 1950, p. 501, 503; Mori, 1963, p. 42; Yanagisawa *et al.*, 1996, p. 45)

**Neumayriceras* sp. (Masatani 1950, p. 501, 503; Masatani and Tamura, 1959, p. 255; Mori, 1963, p. 42; Yanagisawa *et al.*, 1996, p. 45)

**Indosphinctes* cf. *patiniformis* Spath (Masatani, 1950, p. 501; Sato, 1962, p. 60)

**Indosphinctes* sp. (Masatani, 1950, p. 501, 503; Masatani and Tamura, 1959, p. 256; Sato, 1962, p. 35; Mori, 1963, p. 42)

Perisphinctes 3 spp. (Tokunaga and Otsuka, 1930, p. 585, only two forms are illustrated in pl. 10, figs. a, b)

**Perisphinctes* cf. *plicatilis* Waagen (Masatani, 1950, p. 501, 503; Sato, 1962, p. 35; Mori, 1963, p. 42)

**Perisphinctes* (Masatani and Tamura, 1959, p. 256; Mori, 1963, p. 42)

**Dichotomosphinctes* sp. (Masatani, 1950, p. 501, 503; Masatani and Tamura, 1959, p. 256; Sato, 1962, p. 35; Mori, 1963, p. 42)

**Biplices* (or *Dichotomosphinctes*?) sp. (Masatani, 1950, p. 501, 503; Masatani and Tamura, 1959, p. 256; Sato, 1962, p. 35; Mori, 1963, p. 42)

**Lithacoceras* sp. (Masatani, 1950, p. 501, 503; Masatani and Tamura, 1959, p. 256; Sato, 1962, p. 35; Mori, 1963, p. 42; Yanagisawa *et al.*, 1996, p. 45)

***Subdichotomoceras chisatoi* sp. nov. (Figures 7.1, 7.2) = *Subdichotomoceras* sp. nov. (Sato *et al.*, 2005, p. 23, pl. 2, figs. 1, 3)

**Pachysphinctes* sp. (Sato *et al.*, 2005, p. 24)

**Aulacosphinctoides* cf. *steigeri* (Shimizu) (Masatani, 1950, p. 501, 503; Sato, 1962, p. 35; Mori, 1963, p. 42)

**Aulacosphinctoides* sp. (Masatani and Tamura, 1959, p. 256)

Aulacosphinctoides? sp. senile (Sato *et al.*, 2005, p. 22, pl. 1, fig. 2)

**Pseudopeltoceras* sp. (Masatani, 1950, p. 501, 503; Masatani and Tamura, 1959, p. 256; Sato, 1962, p. 35; Mori, 1963, p. 42)

Aspidoceras sp. (Sato *et al.*, 2005, p. 26, pl. 4, fig. 8)

Pseudowaagenia? or *Pachypictonia*? sp. (Sato *et al.*, 2005, p. 26, pl. 4, figs. 9, 10)

Simoceras? sp. (Tokunaga and Otsuka, 1930, p. 585, pl. 10, fig. c) horizon uncertain

Middle coarse sandstone member, level A3

***Holcophylloceras* sp. (Figure 5.1) (= Sato *et al.*, 2005, p. 21, pl. 2, fig. 4)

***Haploceras* sp. (Figures 5.2, 5.4, 5.5) (= Sato *et al.*, 2005, p. 24, pl. 4, figs. 1–3)

Taramelliceras nov. sp. (Sato, 1962, p. 35, 70, pl. 3, fig. 4)

Taramelliceras sp. (Sato *et al.*, 2005, p. 25, pl. 4, figs. 5–7)

**Neumayriceras* sp. = cf. *Taramelliceras* (Masatani, 1950, p. 502, 503; Masatani and Tamura, 1959, p. 255)

**Streblites* sp. (Masatani, 1950, p. 502, 503; Sato, 1962, p. 35; Mori, 1963, p. 42)

***Subdichotomoceras chisatoi* sp. nov. (Figures 8.1–8.6) = *Subdichotomoceras* sp. nov. microconch (Sato *et al.*, 2005, p. 23, pl. 2, fig. 2) = *Subdichotomoceras* sp. (Sato *et al.*, 2005, p. 23, pl. 3, figs. 1–5)

**Pachysphinctes* sp. (Sato, 1962, p. 36)

Pachysphinctes sp. (Sato, 1962, p. 61, pl. 10, fig. 4)

Pachysphinctes sp. (Sato *et al.*, 2005, p. 24, pl. 3, figs. 6–8)

**Aulacosphinctoides* cf. *steigeri* (Shimizu) (Masatani,

1950, p. 502, 503; Sato, 1962, p. 35)
****Aulacosphinctoides tairai*** sp. nov. (Figures 6.1, 6.2, 6.4, 6.5) = *Aulacosphinctoides* sp. nov. macroconch (Sato *et al.*, 2005, p. 22, pl. 1, fig. 1) = *Aulacosphinctoides* sp. (Sato *et al.*, 2005, p. 22, pl. 1, figs. 3, 6) = *Aulacosphinctoides*? sp. (Sato *et al.*, 2005, p. 22, pl. 1, fig. 4).
Aulacosphinctoides (Masatani and Tamura, 1959, p. 255)
Virgatosphinctes sp. indet. (Masatani, 1950, p. 502, 503; Sato, 1962, p. 35; Mori, 1963, p. 42; Yanagisawa *et al.*, 1996, p. 45)
Aspidoceras sp. (Masatani, 1950, p. 502, 503; Masatani and Tamura, 1959, p. 255; Sato, 1962, p. 35; Mori, 1963, p. 42; Yanagisawa *et al.*, 1996, p. 45)
****Hybonoticeras*** sp. (Figures 5.6–5.8) (= Sato *et al.*, 2005, p. 26, pl. 4, figs. 11–13)

Koike Limestone Member, level A4

****Haploceras*** sp. (Figure 5.3) (= Sato *et al.*, 2005, p. 24, pl. 4, fig. 4)
Streblites sp. nov. (Shimizu, 1931, p. 13, figs. 1, 2; Sato, 1962, p. 35, 60) = ***?Haploceras*** sp. (Sato *et al.*, 2005, p. 20)
Virgatosphinctes sp. = *Perisphinctes* (*Virgatosphinctes*) sp. indet. (Shimizu, 1930, p. 46, pl. 6, figs. 1–3; Sato, 1962, p. 35), identification uncertain, specimen incomplete
Aulacosphinctoides cf. *steigeri* (Shimizu) = *Perisphinctes* (Aulacosphinctes) cfr. *Steigeri* (Shimizu, 1928, p. 219, figs. 1, 2; Shimizu, 1930, p. 45, pl. 6, figs. 4, 5; Masatani and Tamura, 1959, p. 253; Sato, 1962, p. 35; Yanagisawa *et al.*, 1996, p. 45)
****Aulacosphinctoides tairai*** sp. nov. (Figure 6.3)
Aulacosphinctoides sp. juv. (Sato, 1962, p. 93, pl. 10, figs. 6, 7)
Aulacosphinctoides sp. (Sato *et al.*, 2005, p. 22. pl. 1, fig. 5)

Koyamada Formation, level A5

Perisphinctes (Masatani, 1950, p. 502; Masatani and Tamura, 1959, p. 255; Sato, 1962, p. 35; Mori, 1963, p. 44)
Perisphinctes (*Paraboliceras*?) *japonicus* Yabe (Yabe, 1943, p. 582, fig. 1; Masatani, 1950, p. 502, 503; Sato, 1962, p. 35; Mori, 1963, p. 44) = *Berriasella* sp. (Sato, 1961 a, b, p. 545, pl. 12, figs. 3, 4; this identification cannot be accepted).
Paraboliceras cf. *fascicostatus* Uhlig (Masatani, 1950, p. 502, 503; Masatani and Tamura, 1959, p. 255; Sato, 1962, p. 35; Mori, 1963, p. 44; Yanagisawa *et al.*, 1996, p. 48)
Virgatosphinctes sp. (cf. *V. rotundicum* Uhlig) (Masatani, 1950, p. 502, 503; Masatani and Tamura, 1959, p. 255; Sato, 1962, p. 35; Mori, 1963, p. 44)
****?Spiticeras** sp. juv. (Figure 5.9) = *Spiticeras* sp. juv. (Sato *et al.*, 2005, p. 26, pl. 5, fig. 1)
Neocosmoceras? akiyamae (Sato) = *Berriasella akiyamae* Sato (Sato *et al.*, 2005, p. 27, pl. 5, figs. 2, 3, pl. 6, figs. 1–3) = ?*Neocosmoceras* sp. (Klein, 2005, p. 218)
Berriasella sp. (Sato *et al.*, 2005, p. 27, pl. 6, figs. 4, 5)
****Dalmasiceras muneoi*** sp. nov. (Figure 9) = *Dalmasiceras* sp. nov. (Sato *et al.*, 2005, p. 27, pl. 7, fig. 1)
Dalmasiceras sp. (Mori, 1963, p. 44)
Substeueroceras? sp. (Sato *et al.*, 2005, p. 28, pl. 7, fig. 2)
Thurmanniceras sp. (Sato, 1961a, b, p. 537, pl. 13, fig. 7; Yanagisawa *et al.*, 1996, p. 48)
Kilianella sp. juv. (Sato 1961b, pl. 13, fig. 3; Sato *et al.*, 2005, p. 28, pl. 7, fig. 3)
Kilianella sp. (Mori, 1963, p. 44)
Parakilianella umazawensis Sato (Sato, 1961a, b, p. 547, pl. 12, fig. 1, pl. 13, fig. 8; Sato *et al.*, 2005, p. 28, pl. 7, fig. 4; Yanagisawa *et al.*, 1996, p. 48)

Geological age suggested by the new fauna

As the above list shows, many of the hitherto known ammonite species are not described paleontologically. They are often based on fragmentary specimens, so that the identification cannot be easily accepted as it is. The geological age suggested by these ammonites has therefore no firm basis. Correlation should be based thereby on careful selection of species of which the identification seems reliable. Some of the species combinations are quite heterogeneous. The new collection offers better criteria, and the geological age of each formation is to some extent more firmly decided.

Awazu Formation: There is no new collection from this formation. The only ammonite it is known to contain is *Bigotites*, which suggests a late Bajocian to early Bathonian age (Sato, 1962; 1992). Later the age of the formation was restricted to the late Bajocian (Sato and Westermann, 1991).

Nakanosawa Formation: Ammonites occur in three different stratigraphical horizons of this formation, as listed above. We will use only described and figured species in the following discussion, putting aside the species only reported.

The level A2, in the lowest ammonite-bearing horizon of the Nakanosawa Formation, is characterized by the association of *Taramelliceras*, *Subdichotomoceras* and *Aspidoceras*. All these genera are known from the Kimmeridgian to early Tithonian (cf. Arkell *et al.*, 1957). It is therefore safe to conclude that the age of level A2 is within the Kimmeridgian – early Tithonian interval.

The assemblage of level A3 includes *Taramelliceras*, *Haploceras*, *Subdichotomoceras*, *Pachysphinctes*, *Au-*

lacosphinctoides and *Hybonoticeras*. We can add *Aspidoceras* to this association, selected from the reported species, because this genus is very characteristic and easy to identify, and its citation is therefore acceptable. All these genera existed in the late Kimmeridgian to early Tithonian (except for *Pachysphinctes*, of which the identification is not definitive). Therefore, this association indicates an age more or less later than that of the A2 fauna. A late Kimmeridgian to early Tithonian age is thus suggested, as this is the common range of the component genera.

The level A4 is characterized by the assemblage of *Aulacosphinctoides*, *Virgatosphinctes* and *Haploceras*, in addition to a *Streblites* of uncertain identification. *Aulacosphinctoides* ranges from late Kimmeridgian to Tithonian, whereas *Virgatosphinctes* is confined to the Tithonian. *Haploceras* is an indicator of the late Kimmeridgian to Tithonian. The age of this assemblage is therefore most probably Tithonian.

Sato and Westermann (1991) assigned an early Tithonian age to the *Aulacosphinctoides* cf. *steigeri* association, but as seen earlier, *Taramelliceras* and *Subdichotomoceras*, both essentially of Kimmeridgian age, coexist with *Aulacosphincoides* in level A3. Therefore, this age assignment should be restudied when more information becomes available. For the time being, the age of the above association should be considered to range from late Kimmeridgian to Tithonian.

Koyamada Formation: The fauna of the Koyamada Formation has a controversial composition. It includes genera of various time ranges, such as *Paraboliceras* of Kimmeridgian to Tithonian age, *Dalmasiceras*, *Substeueroceras*, ?*Spiticeras* and *Berriasella* of late Tithonian to Berriasian age, *Neocosmoceras* of exclusively Berriasian age, *Thurmanniceras* and *Kilianella* ranging from Berriasian to Valanginian (time range mostly after Wright *et al.*, 1996) and *Parakilianella*. Of these, *Substeueroceras* was once described from the Sakamoto Formation in central Kyushu, as an indicator of upper Tithonian age (Sato, 1961a), but the Soma specimen is very poorly preserved and its identification should be considered to be tentative. As *Dalmasiceras* is represented by a new species and *Parakilianella* is an indigenous Japanese genus, these two genera cannot be used as the basis of worldwide correlation. Yabe (1943) cited Zusahara (Jisahara) as its place of occurrence, but unfortunately without a detailed indication of the spot. Therefore, it is not certain whether it represents an independent horizon or not.

Recently Klein (2005) suggested that *Berriasella akiyamae* from the Isokusa Formation in Kesennuma-Oshima is a form belonging to *Neocosmoceras*. This genus is exclusively of Berriasian age. Therefore the existence of *Berriasella akiyamae* in the assemblage of level A5 indicates positively Berriasian age.

The new ammonite fauna of the Koyamada Formation is only known from Locality 10 at Umazawa, representing level A5. As the assemblage includes genera of different ages, some mixing of ammonite fossils of different ages seems to have occurred at the time of deposition. If the mixing of the faunal elements does exist, level A5 of the Koyamada Formation should be attributed to the age of the youngest species. However, as sedimentary mixing is as yet not proven, it is safe at least tentatively to judge that level A5 of the Koyamada Formation is Berriasian in age, which is the common time range of the above genera.

Paleobiogeographical consideration

All the elements cited above are of Tethys - Pacific affinity. There are no Arctic elements in the present fauna. It should be noted that important elements of the Nakanosawa fauna, such as *Aulacosphinctoides*, *Subdichotomoceras* and *Pachysphinctes* of the subfamily Virgatosphinctinae, are prolific in the Cutch and Himalayan areas, as well as in the Submediterranean region including Madagascar, Kenya, North Africa and South Europe. Some of these Submediterranean elements extend further eastward, passing Southeast Asia and Japan, reaching Middle and South America. This is not inconsistent with other elements, like *Hybonoticeras* and *Aspidoceras*, which are widely known from the Tethys Sea. *Holcophylloceras* has a worldwide distribution, and is abundantly known from the Pacific, including the Japanese Jurassic.

The Koyamada Formation shows the same tendency. Berriasellid ammonites are prolific in the Tethys Ocean, as they are reported abundantly from South Europe, North Africa, Turkey, the Himalayas and contingent areas. There are no Arctic elements either.

Systematic descriptions of newly found species

The new collection includes many well preserved specimens of previously described species which ensure the previous identifications. In addition, there are some new forms which have never been reported before. Systematic descriptions of new species and hitherto unknown species are given below. Species which had already been described elsewhere are not included. The classification of the major taxa (except Phylloceratina) is according to Donovan *et al.* (1981), and the genera within a given family (subfamily) are arranged according to Arkell *et al.* (1957) or Wright *et al.* (1997).

The following abbreviations are used throughout the

descriptions. D, Diameter; UD, Diameter of umbilicus; H, Height of whorl; W, Width of whorl; UD/D, Ratio of umbilical diameter to diameter.

Specimens described in this paper are housed in the following museums. Fukushima Museum at Aizuwakamatsu City (FM), Kashima History Folklore Museum at Minamisoma City (KHFM) and Minamisoma Museum at Minamisoma City (MM).

Order Ammonoidea Zittel, 1884
Suborder Phylloceratina Arkell, 1950
Superfamily Phylloceratina Zittel, 1884
Family Phylloceratidae Zittel, 1884
Genus ***Holcophylloceras*** Spath, 1927

Type species.—*Phylloceras mediterraneum* Neumayr, 1871

Holcophylloceras sp.

Figure 5.1

Holcophylloceras sp., Sato *et al.*, 2005, p.21, pl. 2, fig.4.

Material.—A fragmentary outer whorl (KHFM coll. cat. no. 220012) collected by M. Taira from the Kabesu Forestry Road in Koyamada (Locality 3).

Measurements.—Too fragmentary to measure necessary dimensions; observable maximum size is about 65 mm.

Description and remarks.—Overall whorl characteristics are unknown because the specimen consists only of about a half of the last whorl, but the whorls are involute and have flat flanks on which three geniculated constrictions are clearly discernible. This feature indicates that the specimen belongs to the genus *Holcophylloceras*.

Geologic formation.—Nakanosawa Formation. Level A3, below the Koike Limestone.

Geologic age.—This genus ranges widely in the interval Bajocian to Early Cretaceous.

Suborder Ammonitina Hyatt, 1889
Superfamily Haploceratacea Zittel, 1884
Family Haploceratidae Zittel, 1884
Genus ***Haploceras*** Zittel, 1870

Type species.—*Ammonites elimatus* Oppel, 1865; subsequent designation by Spath, 1923.

Haploceras sp.

Figures 5.2–5.5, 5.3a

cf. *Streblites* sp., Shimizu, 1931, p. 13, text-figs. 1–2.
Haploceras sp., Sato *et al.*, 2005, p. 24, pl. 4, figs. 1–3.
Haploceras sp. juv., Sato *et al.*, 2005, p. 24, pl. 4, fig. 4.

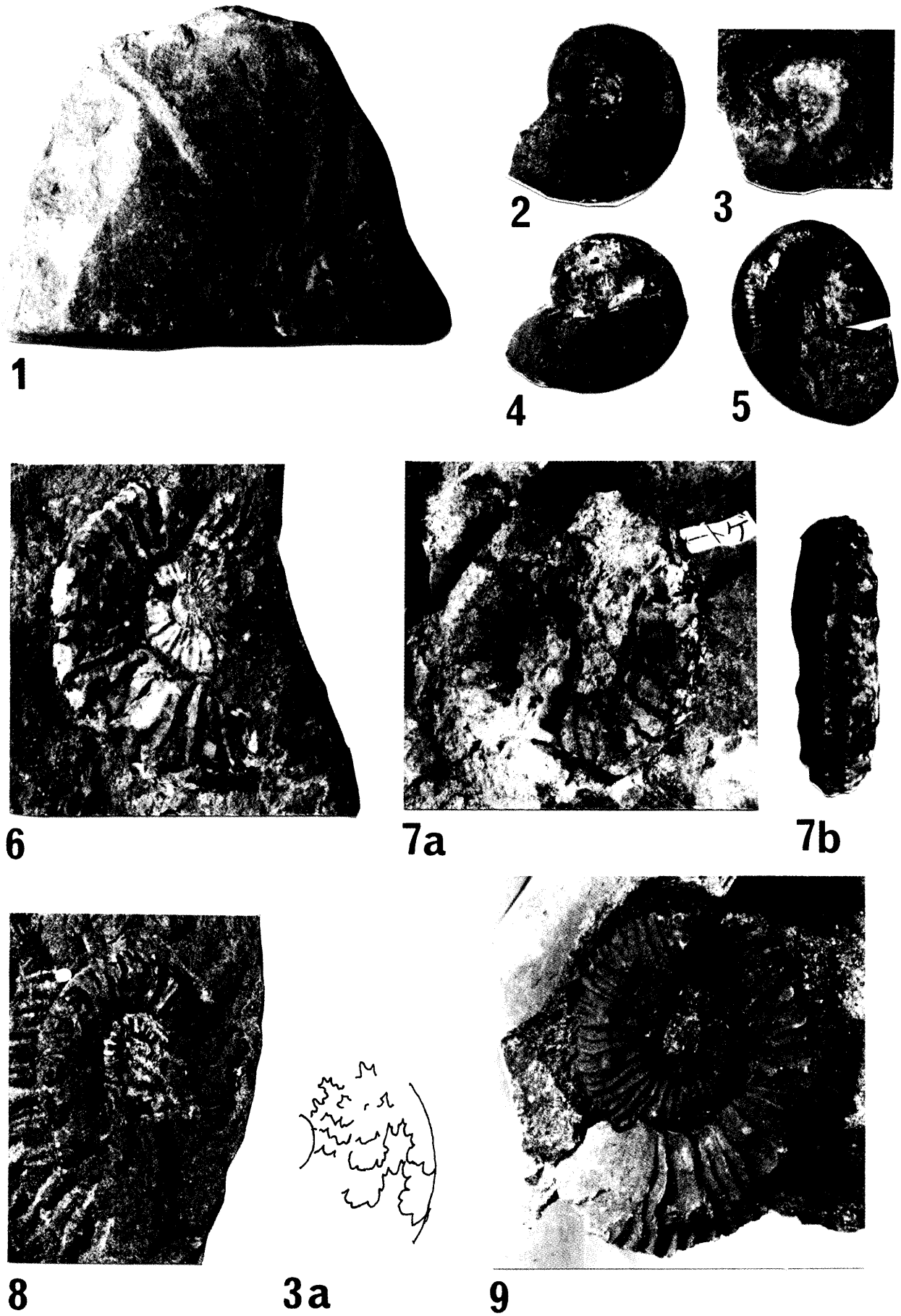
Material.—About twenty specimens from various localities in Minamisoma and Soma cities. Only figured specimens are listed below. KHFM coll. cat. no. 220010 (Figure 5. 2) collected by M. Taira (Locality 5); KHFM coll. cat. no. 220011 (Figure 5. 3) collected by M. Taira (Locality 3); FM coll. cat. no. N200500639 (Figure 5. 4) collected by Y. Ara (Locality 7); FM coll. cat. no. N200500640 (Figure 5. 5) collected b Y. Ara (Locality 1).

Measurements (*in mm*).—KHFM-220010: D 20; UD 5; H 9; W 5.5; KHFM-220011: D 3.2; UD 1; H 5.5; W 4.2; FM-N200500639: D 28; UD 4; H 7; W ?; FM-N200500640 : D 20.5; UD 4; H 11.5; W 7.

Description.—Whorls small, coiling involute; whorl section elliptical, inflated at the middle flank; ventral region rounded; shell generally smooth; faint falcoid ribs on the flank which are more prominent in the ventrolateral region; suture lines moderately incised, with a few elements, characterized by dominant L1, followed by L2 and L3, both relatively small in size, and decreasing gently towards the umbilical margin.

Comparison.—The present specimens are all small in size and generally smooth, and rather difficult to identify. However, one specimen (no. KHFM 220011) in the new collection shows well preserved suture lines which constitute a few elements, generally deeply incised, and gradually declining auxiliary lobes. It is definitely different from the *Streblites*-style suture lines with numer-

➡ **Figure 5.** Ammonites from the Somanakamura Group (Part 1). 1–8: from the Nakanosawa Formation, 9: from the Koyamada Formation. Numbers in parentheses indicate those cited in Sato *et al.*, 2005. **1.** *Holcophylloceras* sp., KHFM coll. cat. no. 220012 (specimen: #170), Kabesu Forestry Road, Koyamada, × 1. **2–5.** *Haploceras* sp. 2. KHFM coll. cat. no. 220010 (specimen: #99), north side cliff of the Kamimano River, Koike, × 1.5. 3. KHFM coll. cat. no. 220011 (specimen: #110), Kabesu Forestry Road, Koyamada, × 2. 3a. Suture lines on the last part of phragmocone of *Haploceras* sp. (specimen KHFM coll. cat. no. 220011). 4. FM coll. cat. no. N200500639 (specimen: #133), Tatenosawa Forestry Road, Koike, × 1. 5. FM coll. cat. no. N200500640 (specimen: #134), limestone quarry, Tomizawa, × 1.5. **6–8.** *Hybonoticeras* sp. 6. FM coll. cat. no. N200500626 (specimen: #137), Tatenosawa Forestry Road, Koike, × 1.5. 7. KHFM coll. cat. no. 220016 (specimen: #156), Tatenosawa Forestry Road, Koike, lateral (a) and ventral (b) views, × 1.5. 8. KHFM coll. cat. no. 220013 (specimen: #182), Tatenosawa Forestry Road, Koike, × 1.5. **9.** ?*Spiticeras* sp. juv., KHFM coll. cat. no. 220015 (specimen: #114), Umasawa, Koyamada, × 1.5.



ous elements, and can be compared with the *Haploceras* type (Figure 5.3a). A small and smooth ammonite was once described by Shimizu (1931) as a new species of *Streblites* from the Koike limestone bed. It is a single tiny specimen, ornamented with faint falcoid ribs on the flanks, passing through the ventral region with a forward projection. One of the authors (TS) was able to examine the original specimen by the courtesy of Prof. Ehiro, director of the Tohoku University Museum, but could not identify it with certainty because it is not sufficiently well preserved and appears to be a juvenile individual. Moreover, the suture line is not observable as the original author described. This specimen seems not to have numerous secondary ribs (which are one of the important specific characters, as Arkell *et al.* (1957) mentioned). Shimizu's species should be transferred rather to *Haploceras*.

Haploceras has not been described from the Japanese Jurassic, consequently it is worth reporting in this paper though the specimens are not good enough.

Geological formation.—Nakanosawa Formation, basal part of the Koike Limestone Member (level A4) and the uppermost part of the Tatenosawa Sandstone Member (level A3).

Geological age.—Late Kimmeridgian to early Tithonian.

Family Aspidoceratidae Zittel, 1895
Subfamily Hybonoticeratinae Donovan, Callomon and Howarth, 1981
Genus ***Hybonoticeras*** Breistroffer, 1947

Type species.—*Ammonites hybonotus* Oppel, 1863.

Hybonoticeras sp.

Figures 5.6–5.8

Hybonoticeras sp., Sato *et al.*, 2005, p. 26, pl. 4, figs. 11–13.

Material.—Three specimens from the Tatenosawa Forestry Road in Koike, Kashima-ku, Minamisoma City (Locality 7). FM coll. cat. no. N200500626 (Figure 5. 6) collected by C. Suzuki; KHFM coll. cat. no. 220016 (Figure 5. 7) collected by M. Sasaki; KHFM coll. cat. no. 220013 (Figure 5. 8) collected by M. Taira.

Measurements (*in mm*).—FM-N200500626: D 35; UD 14; H 13.2; W ?; KHFM-220013: D 25; UD 10; H 10; W ?; KHFM-220016: D 28.6; UD 10; H 8; W 7.3.

Description.—Shell small, probably immature, coiling rather evolute, whorl section compressed quadrate, with sulcate venter; two rows of tubercles on both sides of the ventral sulcus; flanks flat, ornamented by distant, stout bituberculate ribs; tubercles on umbilical and ventral margins, and sometimes spiny at the ventral margin; ventral tubercles sometime forming loops with neighbors; suture lines unknown.

Remarks.—Though the specimens available are fragmentary, the characteristic whorl shape and ornamentation indicate that they belong to the genus *Hybonoticeras*. They reveal in some respects *H. knopi* (Neumayr), which is characterized by blunt straight ribs on the flank which are superposed by needlelike tubercles on both ventral and umbilical margins (cf. Berckhemer and Hölder, 1959, pl. 1, fig.4). Most probably these specimens can be referred to as *Hybonoticeras* sp. juv. ex gr. *beckeri* (Neumayr). However, definite specific identification is not possible at the moment because the studied specimens are too poorly preserved. More specimens are needed for further study. This genus has never before been reported from the Somanakamura Group. Recently it was reported from the exotic block of sandy siltstone of the Oriai Formation in SW Shikoku (Takei and Matsuoka, 2004).

Geologic formation.—Upper part of the Nakanosawa Formation, at the horizon just below the Koike Limestone Member (level A3).

Geologic age.—Probably latest Kimmeridgian.

Family Olcostephanidae Haug, 1910
Subfamily Spiticeratinae Spath, 1924
Genus ***Spiticeras*** Uhlig, 1903

Type species.—*Ammonites spitiensis* Blanford, 1863.

?Spiticeras sp. juv.

Figure 5.9

Spiticeras sp. juv., Sato *et al.*, 2005, p. 26, pl. 5, fig. 1.

Material.—KHFM coll. cat. no. 220015 collected by M. Taira from Umasawa in Koyamada, Kashima-ku, Minamisoma City (Locality 10).

Measurements (*in mm*).—D 33.5; UD 26.5; H 15.0; W 11.5.

Description.—A small, fragmentary specimen representing two volutions of inner

whorls; whorl section probably rounded quadrate; sides ornamented by distant radial ribs; a row of strong tubercles on mid-flank in smaller whorls, then another row at the umbilical margin in more developed whorls; secondary ribs are bi- or trifurcated from the tubercles; strong radial constrictions regularly seen on the flank but without accompanying irregular ribs on both its sides.

Remarks.—A few specimens attributed to *Spiticeras* s.s. cfr. *binodiger* Uhlig were described from the same formation by Sato (1961a, pl. XII, fig. 2; 1961b, pl. XIII,

figs. 1,2). These are also poorly preserved, but attain much larger size, representing a part of the adult whorls. They are characterized by a globular whorl section and strong bituberculate ribbing, which are the most important characteristics of the genus. The present specimen, much smaller and representing the juvenile stage, cannot be identified with certainty.

Geologic formation.—Koyamada Formation, Somanakamura Group (A5 horizon).

Geological age.—Most probably Berriasian.

Superfamily Perisphinctaceae Steinmann, 1890
Family Ataxioceratidae Buckman, 1921
Subfamily Virgatosphinctinae Spath, 1923
Genus ***Aulacosphinctoides*** Spath, 1923

Type species.—*Aulacosphinctes infundibulus* Uhlig, 1910.

Aulacosphinctoides tairai sp. nov.

Figures 6.1–6.6

cf. *Perisphinctes* (*Aulacosphinctes*) cfr. *steigeri* Shimizu, 1928, p. 219, figs. 1, 2; Shimizu, 1930, p. 45, pl. VI, figs. 4, 5.
cf. *Aulacosphinctoides* cf. *steigeri* Shimizu. Kobayashi, 1935, p. 74, pl. XIII, fig. 1; Sato, 1962, pl. X, fig. 10.
cf. *Aulacosphinctoides* sp. juv., Sato, 1962, p. 93, pl. X, figs. 6, 7.
Aulacosphinctoides sp. nov., Sato *et al.*, 2005, p. 22, pl. 1, figs. 1a, b.
Aulacosphinctoides sp., Sato *et al.*, 2005, p. 22, pl. 1, figs. 3a, b, 6.
Aulacosphinctoides? sp., Sato *et al.*, 2005, p. 22, pl. 1, figs. 2, 4.

Material.—More than ten specimens from many localities in Soma and Minamisoma cities.

Holotype.—KHFM coll. cat. no. 220001 (Figure 6. 1) collected by M. Taira from the north side cliff of the Kamimano River, Koike (Locality 5).

Paratypes.—MM coll. cat. no. 000049-49-186-002 (Figure 6. 2), collected by Y. Ara (Locality 1); KHFM coll. cat. no. 220003 (Figure 6. 3) collected by M. Taira (Locality 6); KHFM coll. cat. no. 220006 (Figure 6. 4) collected by M. Taira (Locality 8); KHFM coll. cat. no. 220007 (Figure 6. 5) collected by M. Taira (Locality 8); KHFM coll. cat. no. 220008 (Figure 6. 6) by M. Taira (Locality 4); Many other poorly preserved specimens from various localities.

Derivation of the name.—In honor of Mr. Muneo Taira, collector of the holotype.

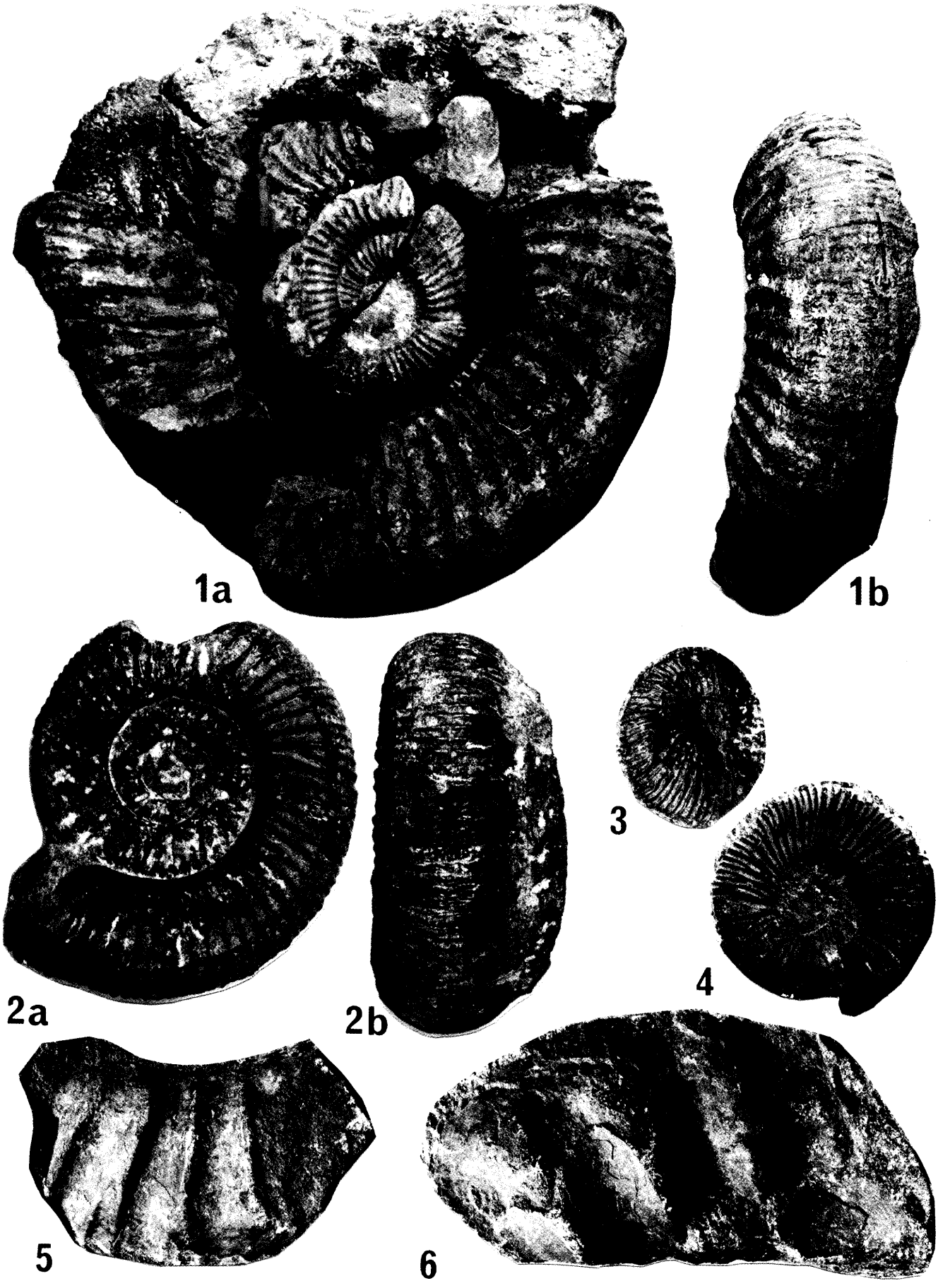
Measurements (*in mm*).—KHFM-220001 (holotype): preserved last whorl: D 141.5; UD 60; H 43; W ca. 35. Inner whorls preserved in the umbilicus: D 49; UD 21; H 20; W 21; MM-000049-49-186-002: D 78; UD 33; H 23.5; W 29; KHFM-220002: D 52; UD 25; H 19.5; W 22; KHFM-220003: D 30; UD 7; H 5; W ?; KHFM-220004: D 27; UD 5; H 13; W 13; KHFM-220005: D 49; UD 23; H 18; W 20; KHFM-220006: D 39; UD 15.5; H 12.5; W 13; KHFM-220007: fragment of senile whorl, H 40; length of preserved whorl 75; D, UD, W unknown; KHFM-220008: fragment of senile whorl, D 61, length of the preserved whorl 88.

Description.—Whorls relatively big in size, coiling evolute, inner whorls depressed elliptic in section and outer whorls rounded quadrate. Ribbing changes gradually toward the outer whorls, but no abrupt change of whorl shape during the ontogeny. Three or more shallow constrictions per whorl, preceded by irregularly branching tri- or bifurcate ribs and followed by simple ribs. Aperture unknown. Ribbing generally sharp, rectiradiate or gently concave forward in general, continuous in the ventral region, with a short backward bend on the umbilical wall; changes gradually toward the outer whorls; first on the inner (immature) whorls ribs are prorsiradiate, generally bi- or triplicate at the ventro-lateral shoulder, with long primaries and short finer secondaries; towards the mature (outer) whorls, the number of triplicate ribs increases, and numerous secondary ribs are fasciculate at the ventro-lateral shoulder, without a clear furcation point. Suture lines characterized generally by deeply incised lobes, particularly by strong stout L1, which is largely tripartite.

Comparison.—The holotype is seemingly a mature individual though somewhat fragmentary, but well preserved enough for detailed observation of the ontogenetic development. The paratypes are also well preserved but do not include the aperture, so that it is impossible to judge whether they are immature relative to the holotype or microconches. However, as the inner whorls of the holotype are quite similar to the paratypes, all the specimens are thought to belong to a single species. The holotype could be a macroconch.

Among the many species classified in this genus, few are of similar size to the holotype, making comparison difficult. *Aulacosphinctoides sisyphi* (Hector) from New Zealand, redescribed and illustrated by Stevens (1997, pl. 27, figs. 1, 2), is a rare example of the macroconches. Its holotype is more than 30 cm in diameter, and shows very similar ribbing, with fasciculate secondary ribs on the adult whorls. The present species should be closely related to the New Zealand species, but the latter is said to be very loosely coiled when the diameter is large (Stevens, 1997, p. 75), which is not ascertained in the Soma form. Though the last whorl of the holotype specimen is loosened this may be due to slight deformation during fossilization.

Shimizu (1928, p. 219, text-figs. 1, 2) described *Perisphinctes* (*Aulacosphinctes*) cfr. *steigeri* from the Koike Limestone bed (the exact horizon is not known). He established a new species *P.* (*A.*) *steigeri* based on *Aulacosphinctes* sp. nov. aff. *lorioli* Zittel described by



Steiger (1914, p. 460, pl. 101, figs. 1, 2) and compared the above Soma form to this species. Shimizu (1930, p. 45, pl.VI, figs. 4, 5) showed another specimen under the same name. Unfortunately these two specimens are not locatable at the moment. Based on his published figures, they seem not to be the same species. At any rate, both are too fragmentary and immature to be identified with certainty. Kobayashi (1935) reported an *Aulacosphinctoides* aff. *steigeri* from the Torinosu Limestone in Kochi. His specimen (Kobayashi, 1935, pl. 13, fig. 1) resembles in fact Shimuzu's specimen (Shimizu, 1930, p. 45, pl. VI, figs. 4, 5), though both are deformed and immature. He changed the generic assignment to *Aulacosphinctoides* on L. F. Spath's suggestion. I was able to examine this specimen and refigured it (Sato, 1962, pl. 10, fig. 12) under the name of *Aulacosphinctoides*? sp. aff. *A. steigeri*.

Because all these previously figured specimens are in fact imperfect and immature, it is practically impossible to identify them with certainty. The present collection includes a nearly complete shell (KHFM-220001) which shows almost the complete ontogenetic development of the whorls. The overall characteristics such as steady and continuous increase of the number of triplicate ribs towards the aperture and clearly discernible constrictions enable us to establish a new species.

Remarks.—The name *Aulacosphinctoides* was first introduced by Spath in 1923 but its designation as a genus appeared later, in 1924. He assigned as its type species *Perisphinctes* (*Aulacosphinctes*) *infundibulus* Uhlig (1910, p. 371) but gave no generic diagnosis. Taxonomy of the Subfamily Virgatosphinctinae has been and is a matter of debate. Arkell *et al.* (1957) already mentioned the confusing state of its classification. In fact, distinction among different genera of the subfamily is difficult. The subfamily is characterized by virgatotome ribbing, as typically seen in *Virgatosphinctes*. However, *Aulacosphinctoides* has no true virgatotome ribbing, but is characterized by rather trifurcate ribs more and more abundant toward outer whorls (e.g., Stevens, 1997). Krishna and Pathak (1993) cited six genera in Virgatosphinctinae, such as *Torquatisphinctes*, *Pachysphinctes*, *Katroliceras*, *Aulacosphinctoides*, *Virgatosphinctes* and *Indodichotomoceras* (established on the basis of *Subdichotomoceras inversum* Spath). Among these genera, *Aulacosphinctoides* is the most appropriate genus for the present form, judged by the characteristics described above.

Geologic formation.—Nakanosawa Formation, mostly in level A3 just below the Koike Limestone, and a few in A4. A fragmentary, senile specimen (KHFM-220008) was discovered from level A2.

Geologic age.—Generally the genus ranges from late Kimmeridgian to early Tithonian, but in the Tethyan region mostly early Tithonian. Early Tithonian was proposed for the *Aulacosphinctoides* cfr. *steigeri* association by Sato and Westermann (1991), but this is by no means definitive (see earlier discussion).

Genus ***Subdichotomoceras*** Spath, 1925

Type species.—*Subdichotomoceras lamplughi* Spath, 1925.

Subdichotomoceras chisatoi sp. nov.

Figures 7.1, 7.2, 8.1–8.6

Subdichotomoceras sp. nov., Sato *et al.*, 2005, p. 23, pl. 2, figs. 1–3.
Subdichotomoceras sp., Sato *et al.*, 2005, p. 23, pl. 3, figs. 1–5.

Material.—Eight specimens collected from four localities in Minamisoma City.

Holotype.—FM coll. cat. no. N200500627 (Figure 7. 1a, b) from the right bank of the Mano River near Oyama (Locality 2) collected by C. Suzuki.

Paratypes.—FM coll. cat. no. N200500628 (Figure 7. 2) collected by C. Suzuki (Locality 2); FM coll. cat. no. N200500641 (Figure 8. 2) collected by Y. Ara (Locality 9); KHFM coll. cat. no. 220017 (Figure 8. 1a, b), 220018 (Figure 8. 3), 220019 (Figure 8. 4), 220020 (Figure 8. 5), all collected by Y. Yamaki (Locality 8); KHFM coll. cat. no. 220009 (Figure 8. 6) collected by M. Taira from Locality 8; Other poorly preserved specimens probably of the same species from various localities of the area.

Measurements (*in mm*).—FM-N200500627 (holotype): D 120; UD 49; H 46; W ?; FM-N200500628: deformed, D 110; UD 44; H ca39; W ?; FM-N200500641:

Figure 6. Ammonites from the Somanakamura Group (Part 2). All specimens are from the Nakanosawa Formation. Numbers in parentheses indicate those cited in Sato *et al.*, 2005. **1–6.** *Aulacosphinctoides tairai* sp. nov. 1. KHFM coll. cat. no. 220001 (specimen: #349) (holotype), north side cliff of the Kamimano River, Koike, macroconch, lateral (a) and ventral (b) views, × 0.8. 2. MM coll. cat. no. 000049-49-186-002 (specimen: #61) (paratype), limestone quarry, Tomizawa, lateral (a) and ventral (b) views, × 1. 3. KHFM coll. cat. no. 220003 (specimen: #103) (paratype), south side slope of the Kamimano River, Koike, × 1. 4. KHFM coll. cat. no. 220006 (specimen: #111) (paratype), Fukono-Nakayama Forestry Road, Fukono, × 1. 5. KHFM coll. cat. no. 220007 (specimen: #104) (paratype), Fukono-Nakayama Forestry Road, Fukono, × 0.8. 6. KHFM coll. cat. no. 220008 (specimen: #112) (paratype), 50 m upstream from the Tachimi-ishi Bridge of the Kamimano River, Jisahara, × 0.8.

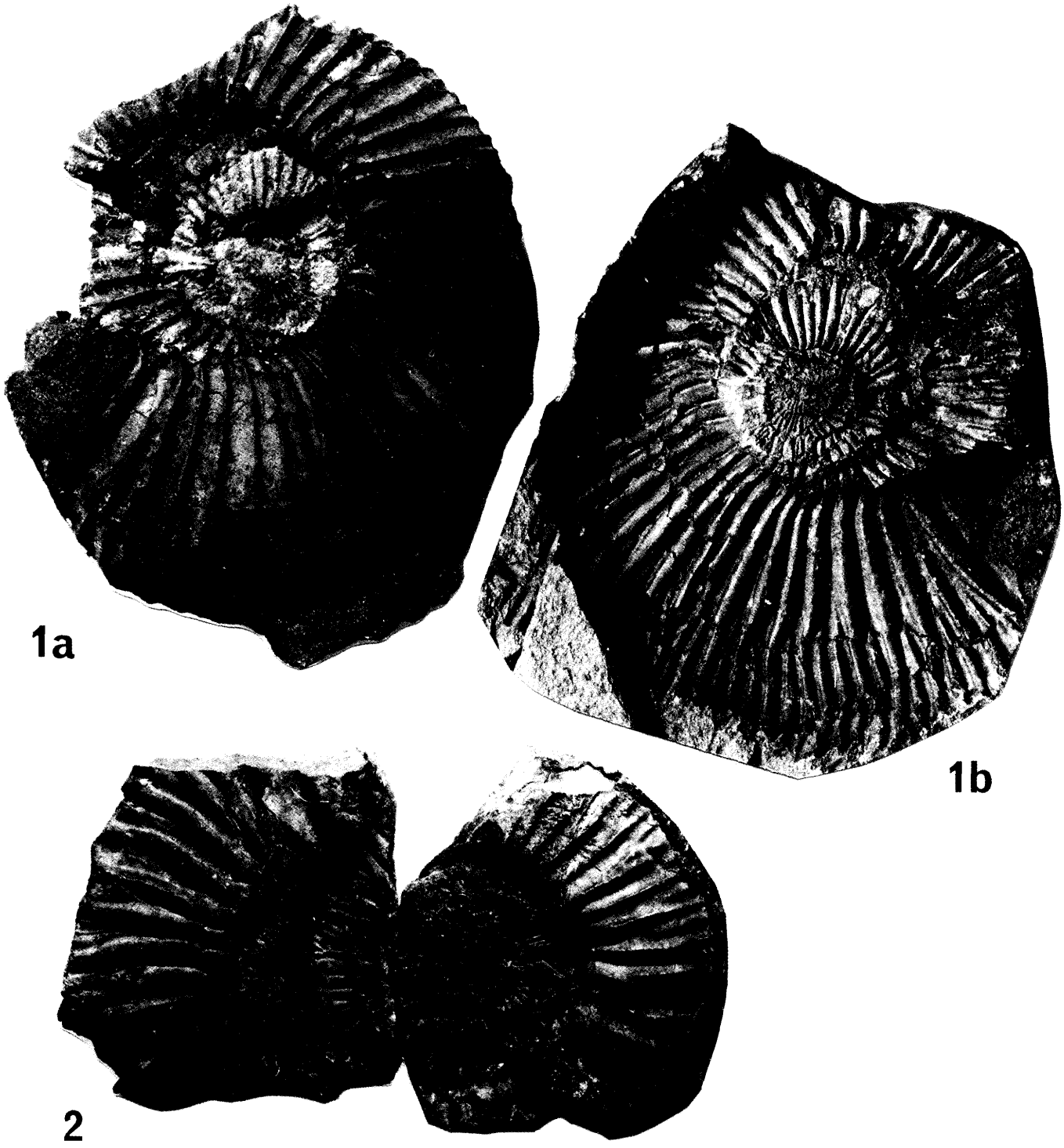


Figure 7. Ammonites from the Somanakamura Group (Part 3). All specimens are from the Nakanosawa Formation. Numbers in parentheses indicate those cited in Sato *et al.*, 2005. **1–2.** *Subdichotomoceras chisatoi* sp. nov. 1. FM coll. cat. no. N200500627 (specimen: #138) (holotype), right bank of the Mano River, Oyama , outer cast (a) and inner mold (b), × 0.8. 2. FM coll. cat. no. N200500628 (specimen: #141) (paratype), right bank of the Mano River, Oyama, × 1.

slightly deformed, D 79; UD 37; H 22; W 26; KHFM-220017: slightly deformed, D 85.5; UD 36.5; H 28; W 21.5; KHFM-220018: D 52; UD 22.5; H 19; W 15; KHFM-220019: D 61.5; UD 25; H ca 21; W ?; KHFM-220020: slightly deformed, D 49; UD 17; H 24; W 14; KHFM-220009: D 56; UD 22; H 16; W 15.

Derivation of the name.—In honor of Mr. Chisato Suzuki, collector of the holotype specimen.

Description.—Whorls evolute to moderately involute with shallow umbilicus; whorl section rounded quadrate, thicker than high in the immature whorls, then higher than wide in the mature whorls; moderately dense and sharp ribs on the flank, unchanged until the aperture, generally rectiradiate and acutely biplicate but some secondaries are simple and inserted sporadically in the ventral region; 2 to 3 deep oblique constrictions per whorl, bordered by irregularly branching or simple ribs. A macroconch (FM-N200500627, Figure 7. 1a, b) is characterized by a strong constriction at the preserved last part of the whorl, while at least one microconch (KHFM-220017) has short lappets at the aperture. General shell features are not different between macroconches and microconches. Suture lines are not preserved.

Comparison.—The type species of the genus, *S. lamplughi* Spath, figured by Arkell *et al.* (1957) in their text-fig. 422, is characterized by sharp and rather coarse distant ribs, which seem unchanged until the aperture, and by strong constrictions bordered by simple ribs. The figured specimen is about 11 cm across in diameter, which is comparable to the size of the present holotype, and seems to preserve the apertural part, which is provided with short, blunt lappets after the deep broad constriction. This feature indicates that the specimen already reaches senility when the ribbing is still much coarser than the Soma species. The outer whorls of the present holotype are slightly deformed and displaced from the original position, but the original ornamentation is preserved. It is definitely finer in ribbing in comparison to the type specimen of *S. lamplughi*.

Subdichotomoceras maraetaiense Stevens (1997), described from the upper Tithonian of New Zealand, is a microconch about 8 cm in diameter, and is provided with short blunt lappets at the apertural region. Ribbing shows somewhat sinuous and biplicate ribs, which are retained until the last part of the whorls. This resembles quite well the Soma species, especially some of the paratypes (for instance, specimen KHFM-220017, Figure 8. 1a, b), which has also short blunt lappets at the apertural region.

Subdichotomoceras mandaranense reported and figured from Madagascar by Collignon (1960, fig. 599) is a big ammonite about 14 cm in diameter, and probably represents the macroconch form of *Subdichotomoceras*. As Collignon noticed, this species can be a transitional form between *Aulacosphinctoides* and *Subdichotomoceras*, but its ribs are always biplicate as far as the figured parts are concerned. It is much bigger in size than the Soma holotype, and the ribbing is much more straight and more distant.

S. chisatoi sp. nov. is judged to be different from all hitherto known *Subdichotomoceras* species, and can be treated as a new species of this genus.

Remarks.—A number of upper Jurassic perisphinctids were cited by previous authors from the Somanakamura Group. Unfortunately, they were mostly not systematically described or figured. Probably comparable forms to this species are included, but the original specimens are not available.

As stated before, the subfamily Virgatosphinctinae comprises many similar genera, such as *Subdichotomoceras*, *Aulacosphinctoides*, *Pachysphinctes*, etc. All these genera look alike, and distinguishing them is generally difficult, especially when the preservation is poor. This is also the case of the Soma ammonites. Better and fully grown specimens are necessary for precise identification.

Krishna and Pathak (1993) proposed a new genus *Indodichotomoceras* for *Subdichotomoceras* species of the Indo-East African province. However, taxonomy of fossils should not be based on provincialism, unless a definite morphological difference is recognized. Stevens (1997) did not accept this genus, remarking that the distribution of *Subdichotomoceras* has no geographical segmentation in the Tethyan province. The writer agrees with his remark, and the genus *Subdichotomoceras* is retained in this paper.

Geologic formation.—Nakanosawa Formation, mostly in its upper part, at the horizon below the limestone bed (level A3), but it ranges down in the middle part (level A2). The holotype is collected from the middle Nakanosawa Formation (level A2).

Geologic age.—Kimmeridgian – early Tithonian.

Family Neocomitidae Salfeld, 1921
Subfamily Berriasellinae Spath, 1922
Genus ***Dalmasiceras*** Djanélidzé, 1921

Type species.—*Ammonites dalmasi* Pictet, 1867; subsequent designation by Roman, 1938.

Dalmasiceras muneoi sp. nov.

Figure 9

Dalmasiceras sp. nov., Sato *et al.*, 2005, p. 27, pl. 7, figs. 1a, b.

Material.—Only one specimen from Umasawa,

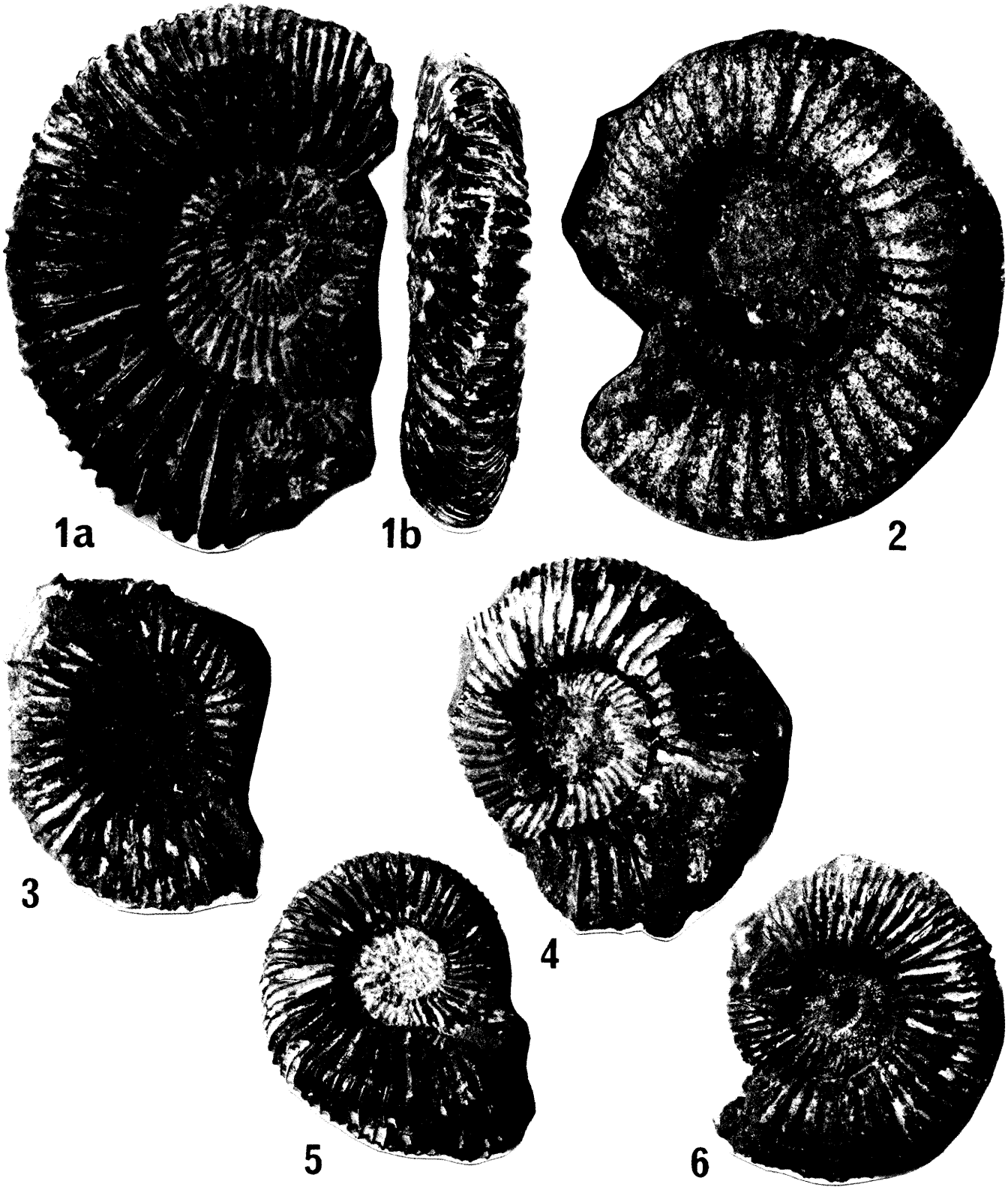


Figure 8. Ammonites from the Somanakamura Group (Part 4). All specimens are from the Nakanosawa Formation. Numbers in parentheses indicate those cited in Sato *et al.*, 2005. **1–6.** *Subdichotomoceras chisatoi* sp. nov. 1. KHFM coll. cat. no. 220017 (specimen: #71) (paratype), Fukono-Nakayama Forestry Road, Fukono, lateral (a) and ventral (b) views, × 1. 2. FM coll. cat. no. N200500641 (specimen: #62) (paratype), valley north of the Fukono-Nakayama Forestry Road, Fukono, × 1. 3. KHFM coll. cat. no. 220018 (specimen: #67) (paratype), Fukono-Nakayama Forestry Road, Fukono, × 1. 4. KHFM coll. cat. no. 220019 (specimen: #69) (paratype), Fukono-Nakayama Forestry Road, Fukono, × 1. 5. KHFM coll. cat. no. 220020 (specimen: #65) (paratype), Fukono-Nakayama Forestry Road, Fukono, × 1. 6. KHFM coll. cat. no. 220009 (specimen: #242) (paratype), Fukono-Nakayama Forestry Road, Fukono, × 1.

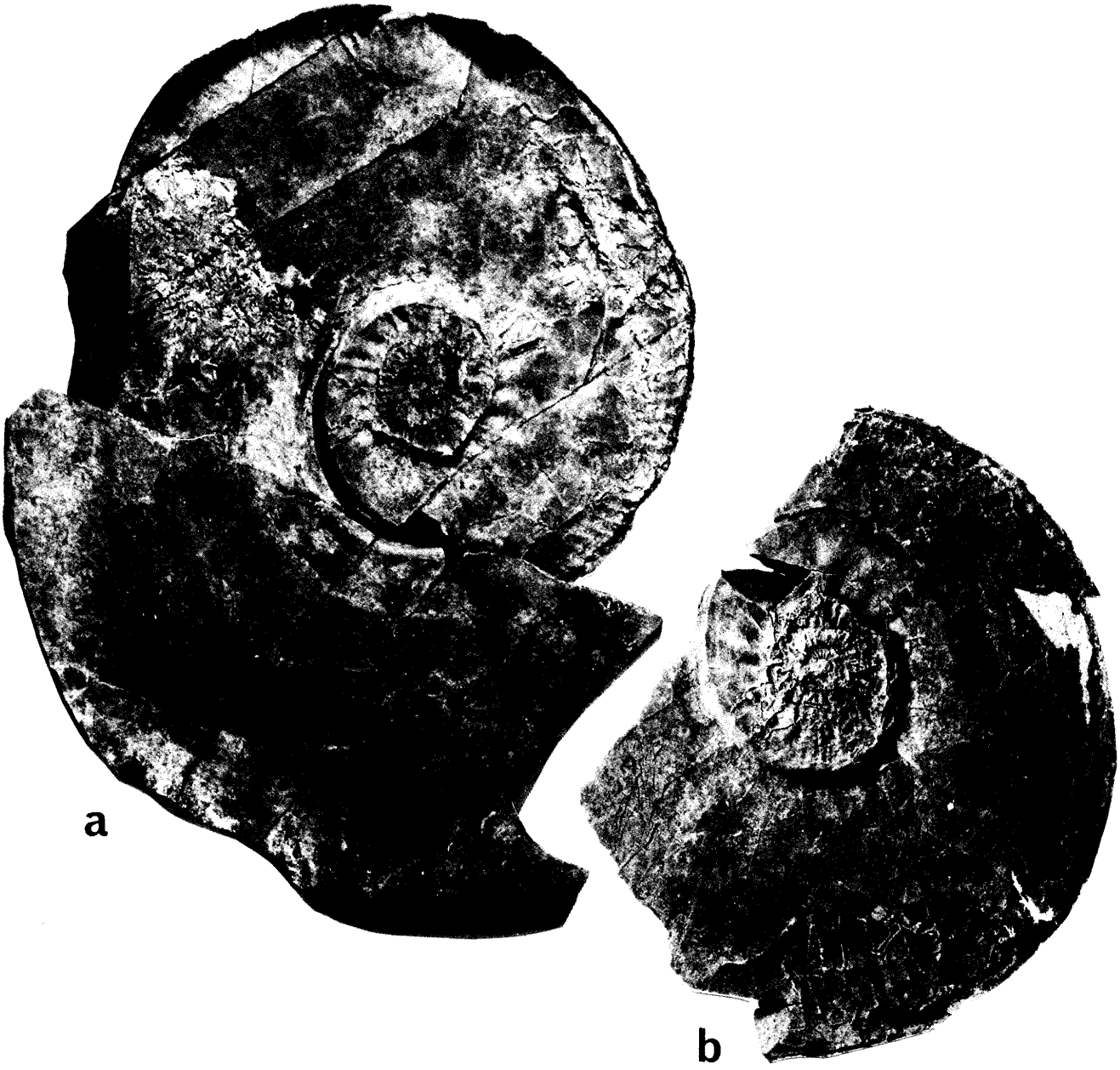


Figure 9. Ammonites from the Somanakamura Group (Part 5). This specimen is from the Koyamada Formation. Numbers in parentheses indicate those cited in Sato *et al.*, 2005. *Dalmasiceras muneoi* sp. nov., KHFM coll. cat. no. 220014 (specimen: #113) (holotype), Umasawa, Koyamada, outer cast (a) and inner mold (b), × 0.8.

Koyamada in Kashima-ku, Minamisoma City (Locality 10).

Holotype.—KHFM coll. cat. no. 220014 collected by M. Taira from Umasawa, Koyamada in Kashima-ku, Minamisoma City (Locality 10).

Measurements (*in mm*).—KHFM-220014 (holotype): D 125.6; UD 34.0; H 42.0; W?

Derivation of the name.—In honor of Mr. Muneo Taira, collector of the holotype.

Description.—Shell large; coiling rather involute with shallow umbilicus (UD/D = 0.25) bordered by vertical umbilical wall; last whorls tend to be less involute (UD/D = 0.27), thus the umbilicus looks elliptical; whorl section is not precisely known by compression, but seems narrowly elliptical, much higher than wide, with maximum thickness at the middle of the flanks and with a narrowly rounded ventral region. Ribbing changes remarkably during ontogenetic development; the phragmocone attains at least 95 mm in diameter, occupying about half of the last preserved whorl; inner whorls,

partly visible in the umbilicus, are costate with rectiradiate stout ribs, with rounded tubercles at the umbilical margin; ribs are likely to be branched into secondaries, but the style of furcation is not observable in the present specimen. The ornamentation changes quickly on the last part of the phragmocone; ribs fade away on the middle flanks, leaving a row of radially elongated tubercles at the umbilical margin, and dense but obtuse secondaries on the peripheral margin. Ribs are almost completely lost on the living chamber, only obtuse remnant secondaries remain on the periphery and are vaguely undulated radially on the flanks.

The suture lines are complex, with strong L1 and S1, followed by rapidly declining auxiliaries; L1 is asymmetrically branched with prominent ventral branch and somewhat weaker umbilical branch; L2 nearly as deep as L1 and complexly frilled.

Comparison.—Subgenus *Dalmasiceras* was created by Djanélidzé (1921) for the coherent group of *Hoplites* (*Dalmasiceras*) *dalmasi* Pictet and *H.* (*D.*) *kiliani* Djanélidzé from Southeast France and the French Alps. Later the subgenus was raised to generic rank. Djanélidzé noticed already a marked change of the shell features and distinguished three or four ontogenetic stages. Many other species attributed to this group have been reported from Southern Europe and North Africa, the Caucasus, Iran, and in addition South America. Elaborated systematic studies were carried out by Mazenot (1939), Le Hégarat (1973) and Nikolov (1982) among others, and all these authors consistently recognized the changing features through ontogeny. The present species from the Somanakamura group follows the same developmental course, attaining finally a nearly smooth stage after the strongly costate and tuberculate stages. This ontogenetic development allows us to classify it in Mazenot's 'Group of *Dalmasiceras progenitor*', especially the subgroup of *D. dalmasi* and *D. punctatum*, which are characterized by a smooth living chamber which retains an umbilical row of tubercles.

D. punctatum (Djanélidzé) from the Berriasian of SE France (Djanélidzé, 1921, pl. 13, fig. 3; Mazenot, 1939, pl. 26, fig. 4) seems comparable to the present species by its smooth last whorl with rounded umbilical tubercles. It is, however, not ribbed in the inner whorls which are observable in the umbilicus. The inner whorls of the Soma specimen are strongly ribbed, even tuberculate on some of the ribs. Moreover, *D. punctatum* is definitely smaller (not more than 85 mm in diameter according to Djanélidzé), thus it cannot be assimilated with the Japanese species. A bigger species, *D. biplanum*, also described from Southeast France by Mazenot (1939, p.174, pl. 26, figs. 8a, b), is comparable in size and smooth last whorl, but it is different from the Soma species by its elongated, concave umbilical margin.

It is therefore justified that the present specimen from the Koyamada Formation represents a new species belonging to *Dalmasiceras*.

Geological formation.—Lower part of the Koyamada Formation (level A5).

Geologic age.—Berriasian.

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