横須賀市博研報 (自然) Sci. Rept. Yokosuka City Mus., (70): 1–38. Mar. 2023

Aptian – Albian (Lower Cretaceous) ammonite assemblages of the Miyako Group in the Sakiyama region, Miyako City, Iwate Prefecture, northeast Japan

MATSUKAWA Masaki * and SHIBATA Kenichiro **

岩手県宮古市崎山地域に分布する下部白亜系宮古層群のアンモナイト化石群集

松川正樹*・柴田健一郎**

キーワード：**アプチアン–アルビアンアンモナイト，系統的記載，宮古層群，崎山地域，*Hypacanthoplites subcornuerianus* 帯，*Diadochoceras nodosocostatiforme* 帯，*Douvilleiceras mammillatum* 帯**

Key words：**Aptian–Albian ammonites, systematic description, Miyako Group, Sakiyama area, *Hypacanthoplites subcornuerianus* Zone, *Diadochoceras nodosocostatiforme* Zone, *Douvilleiceras mammillatum* Zone**

アンモナイトを産する白亜系宮古層群は 5 つの地域に散在して分布する。従って，宮古層群のアンモナイト生層序を構築するために各地域のアンモナイト群集の特徴を理解することが必要である。崎山地域は宮古層群分布域の南部に位置し，岩相層序学的に下位より田野畑層，平井賀層，崎山層に区分される。平井賀層と崎山層の 6 層準から 45 個体のアンモナイトが産出し，新種である *Sanmartinoceras bifurcatum* を含む 17 属 20 種を記載した。この地域の宮古層群から産するアンモナイトは 3 つの群集に細分される。下部の群集は平井賀層，中部の群集は平井賀層最上部～崎山層下部，上部の群集は崎山層上部に含まれる。これらの群集はそれぞれ宮古層群の *Hypacanthoplites subcornuerianus* 帯，*Diadochoceras nodosocostatiforme* 帯，*Douvilleiceras mammillatum* 帯として識別され，西部地中海テチス区のアンモナイト標準化石帯の上部アプチアン～下部アルビアンに相当する。下部と中部の群集では装飾型と平滑型の平面正常巻きが卓越し，上部の群集では装飾型と平滑型の平面正常巻きと異常巻きが含まれる。この変化は，アンモナイト群集がこの地域の海進に伴って多様化したことを示している。

The ammonite-bearing strata of the Miyako Group are distributed discontinuously in five distinct regions. To establish an ammonite biostratigraphy for the Group, it is necessary to understand the characteristics of the ammonite assemblages present in each of the regions. The Sakiyama region is located in the southern part of the Miyako Group's distribution area, and is subdivided lithostratigraphically into three formations in ascending order: the Tanohata, Hiraiga, and Sakiyama

* Department of Environmental Sciences, Tokyo Gakugei University, 4-1-1 Nukuikita-machi, Koganei, Tokyo 184-8501, Japan 東京学芸大学・環境科学分野

** Yokosuka City Museum, 95 Fukadadai, Yokosuka, Kanagawa 238-0016, Japan 横須賀市自然・人文博物館

Manuscript received October 1st, 2022. Contribution from the Yokosuka City Museum. No. 772.

formations. A total of 45 ammonite specimens were found in six lithostratigraphic horizons in the Hiraiga and Sakiyama formations and are classified into 20 species of 17 genera, including one new species, *Sanmartinoceras bifurcatum*. They are described systematically. The ammonites from the Miyako Group in this region are divided into three assemblages: the lower assemblage is included in the Hiraiga Formation; the middle assemblage is included in the sequence from the top of the Hiraiga Formation to the lower part of the Sakiyama Formation; and the upper assemblage is included in the upper part of the Sakiyama Formation. These assemblages are identified as members of the *Hypacanthoplites subcornuerianus*, *Diadochoceras nodosocostatiforme*, and *Douvilleiceras mammillatum* zones of the Miyako Group, respectively, and are assigned to the upper Aptian – lower Albian of the ammonite standard zonation for the West Mediterranean Province of the Tethyan Realm. Ornate planispiral and smooth or weakly ornate planispiral morphologies predominate in the lower and middle ammonite assemblages, and smooth or weakly ornate planispiral and ornate planispiral forms and heteromorph morphologies characterize the upper assemblage. This change indicates that the assemblage diversified during a marine transgression in the area.

INTRODUCTION

Based on ammonite biostratigraphy, the Miyako Group has been shown to include the Aptian – Albian boundary (Obata and Matsukawa, 2018). The precise lithostratigraphic horizon corresponding to the stage boundary has not yet been delimited. As the Miyako Group is distributed discontinuously along the Sanriku coast of the Iwate Prefecture, northern Honshu, Japan, facing the Pacific Ocean, it is necessary to understand and compare the ammonite assemblages in each outcrop region in order to establish a regional ammonite biostratigraphy.

Type area of the Miyako Group is found in the Tanohata region, and the lithostratigraphic division found there has been considered previously to apply to the entire distribution area of the Miyako Group (Hanai *et al*., 1968, and others); in the type area, the Miyako Group is divided lithologically into four formations, in ascending stratigraphic order: the Raga, Tanohata, Hiraiga, and Aketo formations.

The Sakiyama region including the Hideshima coast and the Hideshima Island, represents the southern part of the distribution area of the Miyako Group (Fig. 1). According to Shimazu *et al*. (1970), who revised the stratigraphic interpretation of Hanai *et al*. (1968), the Miyako Group in the Hideshima coast can be divided into three formations in ascending order: the Tanohata, Hiraiga, and Sakiyama formations. Ammonites are found in the strata that of the Hiraiga and Sakiyama formations (Inose *et al*., 2013; Obata and Matsukawa, 2018); some of these ammonite species were described by Shimizu (1931) and Obata and Matsukawa (2018).

This paper describes ammonite specimens from the Sakiyama region, discusses the biostratigraphy and composition of the ammonite assemblages found there, and compares them with the established ammonite biostratigraphy of the Miyako Group (Obata and Matsukawa, 2018), as well as with ammonite assemblages from other Miyako Group localities. Finally, we compare the Sakiyama assemblages with the ammonite biostratigraphy of Aptian – Albian of the Mediterranean Province of the Tethyan Realm, and California of the Pacific Province.

GEOLOGICAL SETTING

1) Distributions and Stratigraphy

The Lower Cretaceous Miyako Group is distributed discontinuously across five regions along the northern Sanriku coast in Iwate Prefecture, northern Honshu Japan (Fig. 1). These regions are located from north to south as follows; (A) the Tanohata region, type are of the group, in Tanohata Village; (B) the Moshi region in Iwaizumi Town and Miyako City, with the ammonite-bearing strata found mainly on small islands off the Moshi coast; (C) the Taro region around Miyako City, where the group is distributed in the hilly area surrounding the Taro settlement; (D) the Sakiyama region, where the group is distributed in a narrow band along the Hideshima coast as

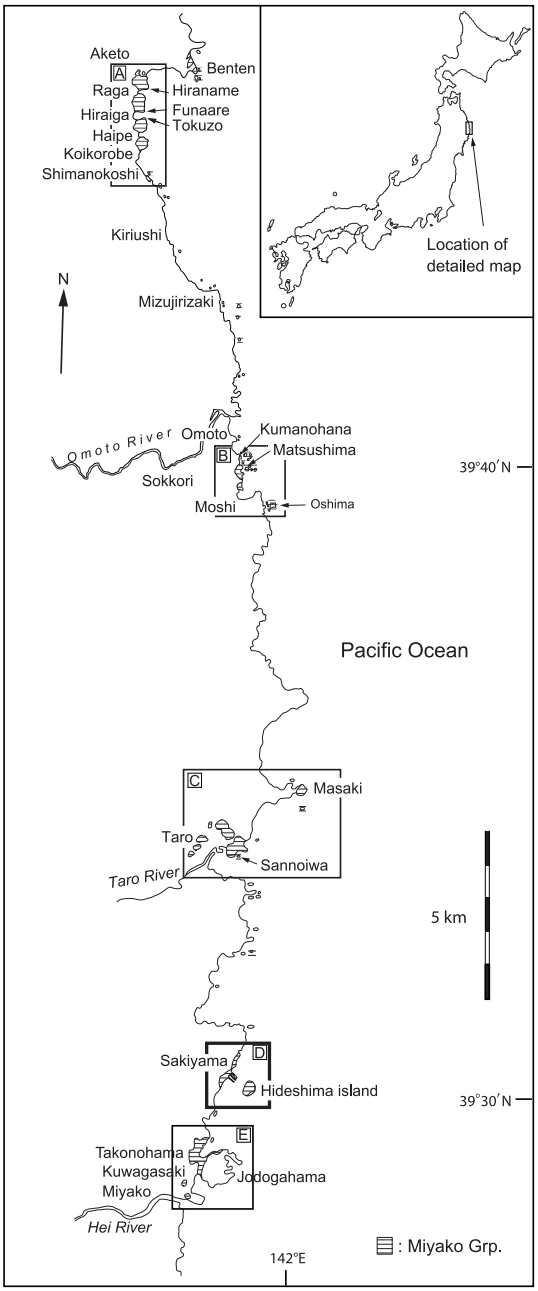

Fig. 1 Map showing the distribution of the Miyako Group in Northeast Japan. After Obata and Matsukawa (2018). The Sakiyama region is D surrounded by a thick line square.

well as on the in Ebisudana and Hideshima islands off the coast; (E) the Miyako region around Miyako City, where the group is exposed discontinuously in Takonohama and Kuwagasaki in Miyako City.

Since Yabe and Yehara (1913) divided the Cretaceous of the Miyako Group into the Raga conglomerate, Moshi sandstone, Tanohata sandy shale, Hiraiga sandstone, *Orbitolina* sandstone, Akito sandstone, and Hideshima sandstone and shale, many geologists, such as Hanai *et al*. (1968), Shimazu *et al*. (1970), Tanaka (1978), Inose *et al*. (2013), Urakawa *et al*. (2016) and Obata and Matsukawa (2018), have discussed and modified these stratigraphic divisions. Although they basically followed the stratigraphic scheme of Yabe and Yehara (1913), Hanai *et al*. (1968) divided the group into the Raga, Tanohata, Hiraiga, and Aketo formations, in ascending order, based on the sedimentary cyclicity seen in the Tanohata region, where each cycle is characterized largely by fining-upward trends.

The Miyako Group unconformably overlies various Lower Cretaceous and older sedimentary and extrusive rocks, which are folded and intruded by granodiorite on the Pacific Ocean side of the northern Kitakami Mountains (Hanai *et al*., 1968; Shimazu *et al*., 1970; Obata and Matsukawa, 2013).

Details of the stratigraphy and facies of the Miyako Group are provided in Obata and Matsukawa (2018). The present paper summarizes the stratigraphy briefly, corrects wrong information, and adds new information about the group.

2) Sakiyama Region

Shimazu *et al*. (1970) applied the lithostratigraphy of Hanai *et al*. (1968) to the successions in the Sakiyama region, with some modifications, and divided the Miyako Group along the Hideshima coast and on Ebisudana Island into the Tanohata, Hiraiga, and Sakiyama formations, in ascending order. The Miyako Group strata found on the Hideshima Island were referred to the Hideshima Formation, as their relationship to other formations in the area was unknown (Shimazu *et al*., 1970). Shimazu *et al*. (1970) regarded that the sequence of the Hiraiga and Sakiyama formations in the Sakiyama region as corresponding to the lower and upper cycles, respectively, of the Hiraiga Formation of the type area in

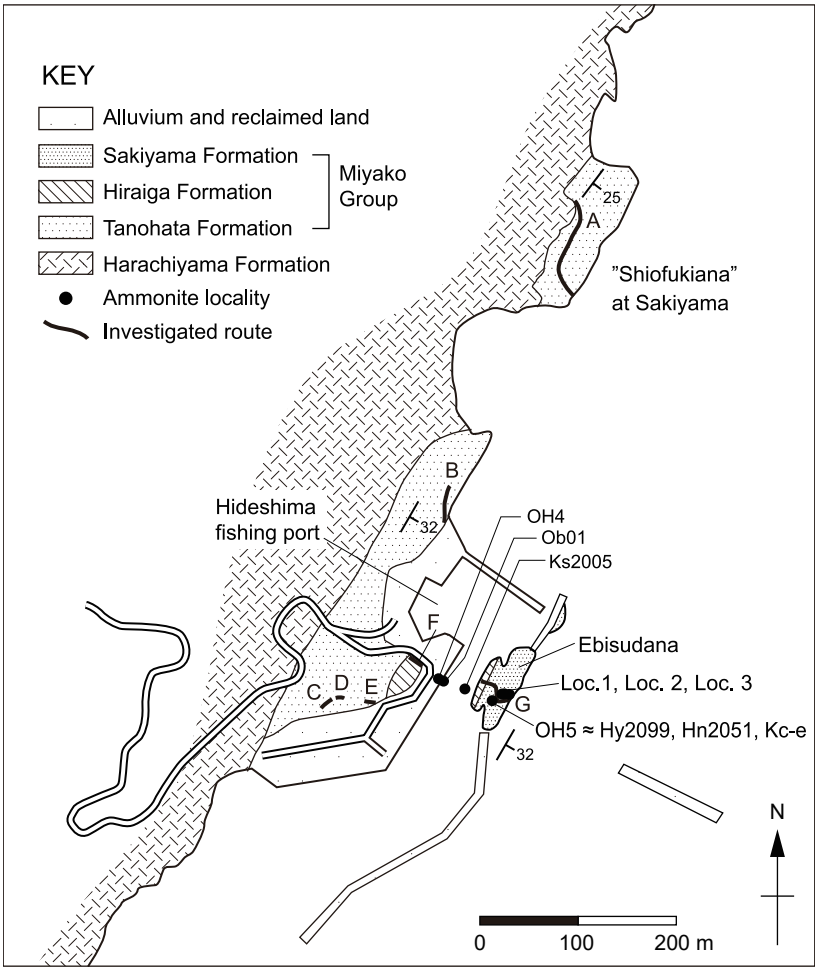

Fig. 2 Geologic map of the Sakiyama region, Miyako City, Iwate Prefecture. See Fig. 1 for the index map. Ammonites described here were collected from the Hiraiga and Sakiyama formations of the Miyako Group. Ammonite localities are also shown.

the Tanohata region, and correlated the sequence to the Hiraiga Formation of the type area of the Miyako Group. In contrast, Inose *et al*. (2013) correlated the Sakiyama Formation in the Sakiyama region to the sequence from the Hiraiga to Aketo formations in the Tanohata region based on ammonite assemblages from the Sakiyama Formation. The ammonite assemblage from the Sakiyama Formation (Inose *et al*., 2013) is similar to that from the locations Hn0650 and Hn6201 in the type Tanohata region (Obata and Matsukawa, 2018). These locations correspond to lithostratigraphic levels of the upper part of the Hiraiga Formation and the lowermost part of the Aketo Formation. This supports the correlation model of Inose *et al*. (2013). A geological map and measured sections of the Miyako Group in the Sakiyama region prepared recently by K. Shibata and M. Matsukawa are presented in Figures 2 and 3, respectively.

LITHOSTRATIGRAPHY OF THE MIYAKO GROUP IN THE SAKIYAMA REGION

(By K. Shibata and M. Matsukawa)

We follow the lithostratigraphy by Shimazu *et al*. (1970) for the most part, with some modifications. The lithostratigraphy is redescribed here.

1) Tanohata Formation

Definition: Composed of conglomerates, pebbly sandstones, cross-stratified sandstones, and sandy

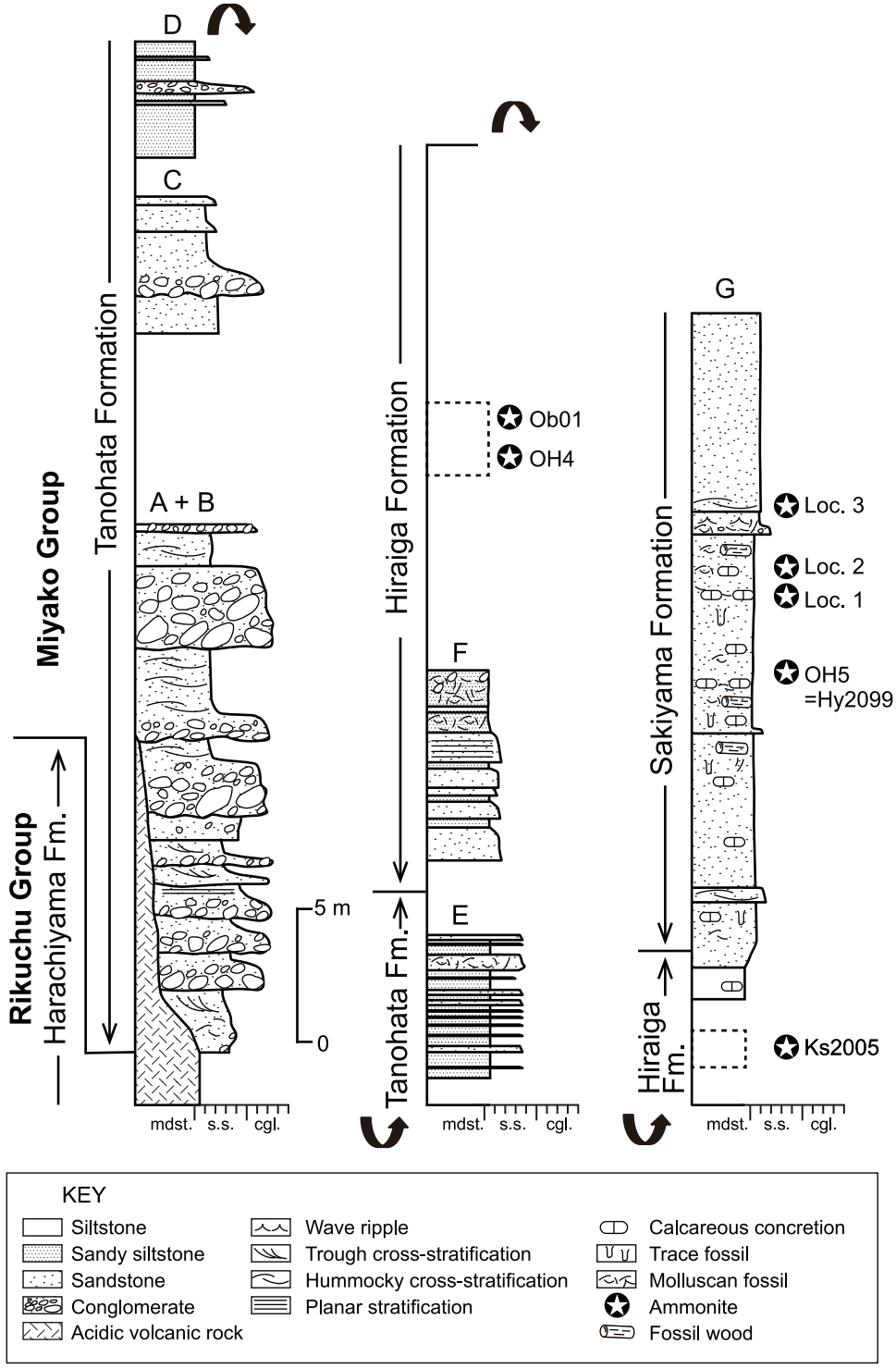

Fig. 3 Generalized columnar section of the Miyako Group in Sakiyama region in Miyako City, Iwate Prefecture. A to G indicate investigated routes in Fig. 2.

mudstones or muddy sandstones (Hanai *et al*., 1968).

Designation: Yabe and Yehara (1913) described the Cretaceous rocks in the Tanohata, Moshi, Taro, and Sakiyama regions, which consist of sandstones and sandy shales under the names of the Moshi sandstone and the Tanohata sandy shale, respectively. Hanai *et al*. (1968) integrated these sandstones and sandy shales to the Tanohata Formation.

Type locality: Hiraiga coast, Tanohata Village, Iwate Prefecture (Hanai *et al*., 1968). This is located in the Tanohata region.

1-1) Tanohata Formation in the Sakiyama Region

Synonymy: Equivalent to the Moshi sandstone by Yabe and Yehara (1913); the sequence of the Lower, Middle, and Upper members of the Tanohata Formation of Shimazu *et al*. (1970), Tanaka (1978), and Tanaka and Obata (1982); lithostratigraphic units 1 and 2 of the Tanohata Formation of Kase (1984); and a lower part of the Tanohata Formation of Obata and Matsukawa (2018).

Thickness: About 38 m.

Distribution: Around the natural monument "Shiofukiana" (Fig. 4A) and western hillsides of parking lots of the Hideshima fishing port (Fig. 4C).

Lithology: In the Sakiyama region, this formation is composed mainly of alternating beds of pebble- to boulder-sized clast-supported conglomerate and coarse- to fine-grained calcareous sandstone. The coarse- and medium-grained sandstone beds, and the fine-grained sandstone beds, exhibit trough cross-stratification and hummocky cross-stratification, respectively. The uppermost part of the formation consists of alternating beds of parallel laminated very fine-grained sandstones and conquinoid coarse-grained sandstones (Fig. 3).

Stratigraphic relationships: Unconformably onlapping basement rocks of the Harachiyama Formation, Rikuchu Group, and conformably overlain by the Hiraiga Formation. In 2022, the boundary between the Tanohata and Hiraiga formations could not be observed, because the boundary outcrop was covered by talus.

Fossil locality: Ks2001 (Kase, 1984)

Remarks: In the Sakiyama region, clasts of conglomerates are boulder to pebble in size, which is larger than in the type area. The ratio of conglomerates relative to sandstones in this area is also greater than in the type area. Sandstones in both the Tanohata and Sakiyama regions exhibit hummocky cross-stratification.

2) Hiraiga Formation

Definition: Composed of well-sorted medium- to fine-grained calcareous sandstones, and locally intercalated mudstones and coquinoid sandstones. In the type area, these sandstones and mudstones change to bioclastic sandstones that include numerous *Orbitolina* sp. in the upper parts and in the northern parts (Hanai *et al*., 1968).

Designation: This formation was originally named the Hiraiga sandstone by Yabe and Yehara (1913) for sandstones exposed at Hiraiga coast, and is considered to conformably overlie the Tanohata sandy shale (upper part of the Tanohata Formation in the present paper) in the Tanohata region. Subsequently, Hanai *et al*. (1968) defined and designated the formation as above.

Type locality: Hiraiga and Raga coasts, Tanohata Village, Iwate Prefecture (Hanai *et al*., 1968).

2-1) Hiraiga Formation in the Sakiyama Region

Synonymy: For the most part, equivalent to the lower part of the Hiraiga sandstone of Yabe and Yehara (1913), the upper part of the first sedimentary cycle of Hayami (1966), the Lower and Upper members of the Hiraiga Formation of Shimazu *et al*. (1970), Tanaka (1978), and Tanaka and Obata (1982), lithostratigraphic units 3 and 4 of the Tanohata Formation of Kase (1984), the "Hiraiga Formation" of Inose *et al*. (2013), and the upper part of the Tanohata Formation of Obata and Matsukawa (2018).

Thickness: About 28 m.

Distribution: Around a small hill southwest of the Hideshima fishing port (Fig. 4B), and on an erosional platform on the west side of Ebisudana Island exposed at low tide (Fig. 4D).

Lithology: The lower part of the formation consists of alternating beds of fine-grained calcareous sandstone and sandy siltstone. The upper part of the formation consists of dark gray, well-sorted siltstone (Fig. 3).

Stratigraphic relationships: Overlying the Tanohata Formation, and overlain by the Sakiyama Formation; the boundary between the Hiraiga and Sakiyama formations is transitional.

Fossil localities: TR43 (Tanaka and Obata, 1982), Hn2058 (Hayami, 1966; Kase, 1984), Hn2065 (Hayami, 1966), TR114 (Tanaka and Obata, 1982), Ks2005 (Kase, 1984), OH4 (present study), and Ob01 (present study).

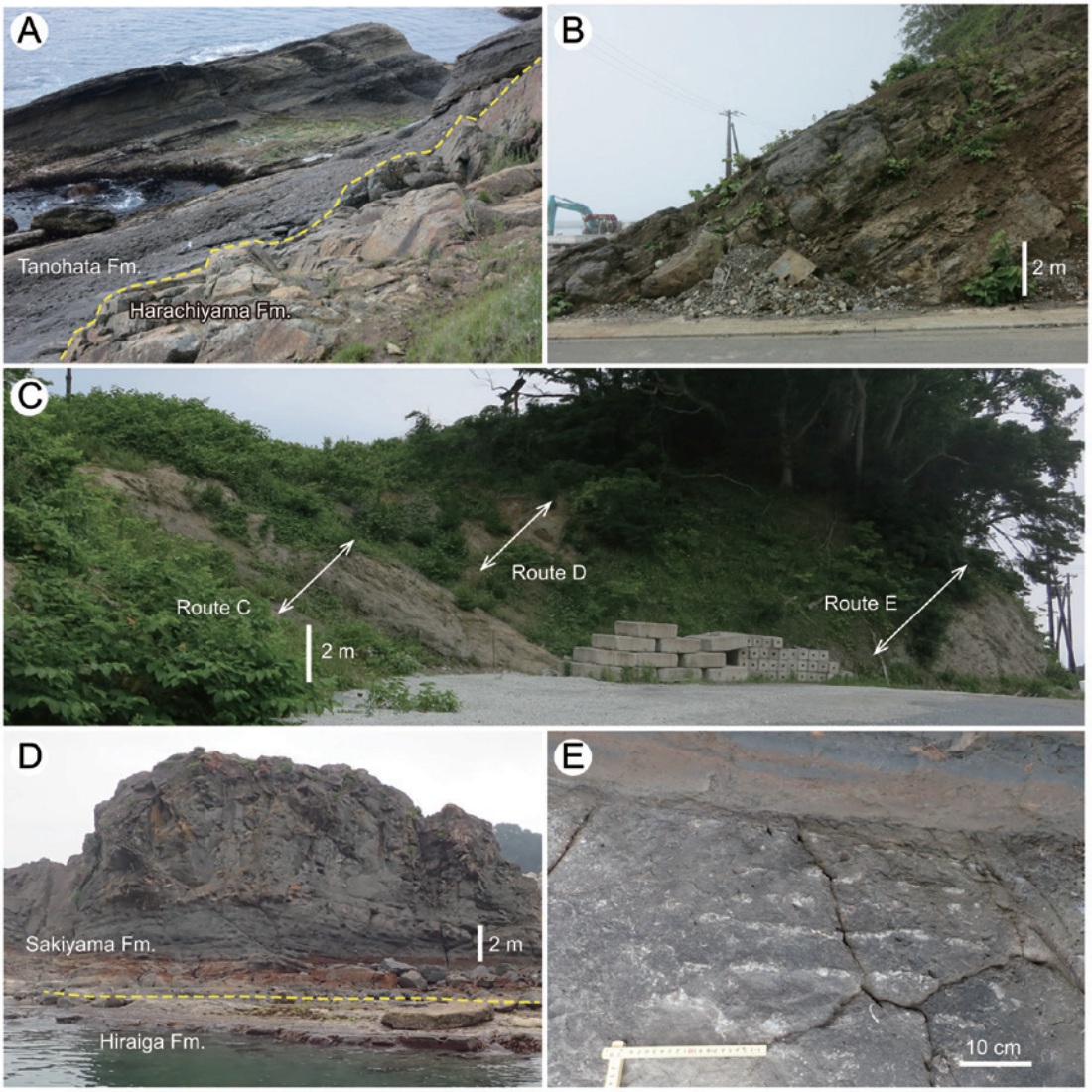

Fig. 4 A, Lower part of the Tanohata Formation overlying the Harachiyama Formation of the Rikuchu Group at "Shiofukiana" at Sakiyama. Taken in June, 2017. Route A in Fig. 2. B, Lower part of the Hiraiga Formation. Taken in June, 2016. Route F in Fig. 2. C, Upper part of the Tanohata Formation. Taken in June, 2017. Routes C, D, and E in Fig. 2. D, Upper part of the Hiraiga Formation and Sakiyama Formation at Ebisudana Islands and the erosional platform. Taken in July, 2022. Route G in Fig. 2. E, Wave ripples in the Sakiyama Formation. Taken in July, 2022. Route G in Fig. 2.

Remarks: In general, the Hiraiga Formation in the Sakiyama region includes more muddy deposits than that in the Tanohata region. Bioclastic sandstones including *Orbitolina* sp. are not found in the Hiraiga Formation in this area.

3) Sakiyama Formation

Definition: Mainly composed of silty sandstones (Shimazu *et al*., 1970).

Designation: This formation was named by Shimazu *et al*. (1970) for sandstones exposed on Ebisudana Island off the Hideshima coast, Sakiyama region.

Type locality: Hideshima coast, Sakiyama, Miyako City, Iwate Prefecture (Shimazu *et al*., 1970).

Synonymy: Generally equivalent to the upper part of the Hiraiga sandstone of Yabe and Yehara (1913), the second sedimentary cycle of Hayami (1966), the Sakiyama

Formation of Shimazu *et al*. (1970), Tanaka (1978), and Inose *et al*. (2013), and the Hiraiga Formation of Kase (1984) and Obata and Matsukawa (2018).

Thickness: More than 20 m.

Distribution: Ebisudana Island, off the Hideshima coast, and an erosional platform on the west side of the Ebisudana Island (Fig. 4D).

Lithology: The formation is composed of poorly sorted, grayish olive-colored (7.5Y5/2 in Munsell color notation), very fine-grained silty sandstones and fine-grained calcareous sandstones. The fine-grained sandstones exhibit hummocky cross-stratification and wave ripples locally (Fig. 4E). Trace fossils and calcareous concretions are common in the sandstones. These sandstones represent an overall coarsening-upward trend (Fig. 3).

Stratigraphic relationships: Gradually transitions from the dark gray siltstone of the Hiraiga Formation. The upper limit of the Sakiyama Formation cannot be observed because the outcrop extends beneath the sea.

Fossil localities: Hn2051 ≈ Hy2099 (Hayami, 1966; Kase, 1984), Locs. 1, 2, and 3 (Inose *et al*., 2013), and OH5 (present study).

Remarks: Lithofacies similar to the Sakiyama Formation are not found in the Tanohata region. Shimazu *et al*. (1970) and Tanaka (1978) regarded fine-grained sandstones about 4 m in thickness in the Taro area as the Sakiyama Formation. In contrast, Matsukawa and Oji (2022) considered the fine-grained sandstones in the Taro area as the upper part of the Tanohata Formation.

FOSSIL LOCALITIES AND THEIR LITHOSTRATIGRAPHIC HORIZONS

In this study, we discuss using ammonite specimens from six lithostratigraphic horizons in five different localities (Figs. 2 and 3) as well as specimens illustrated in previous works. The fossil localities are described in lithostratigraphic order from lowest to highest as follows.

1) OH4; The Hiraiga Formation. The lithology of the site consists of dark gray to black muddy sandstone with piece of wood and mud flakes. Ammonite specimens were collected by Dr. I. Obata in the 1960s. A newly constructed pier at the fishing port currently covers the site. In Obata and Matsukawa (2018; fig. 2), the site of OH4 is illustrated as almost the same site as the site of Hn6201, B2, Hiraname-dana in the Tanohata region; the site as described here is correct.

2) Ob01; The Hiraiga Formation. This site is located on the eastern margin of the land area, and is referred to as the Hideshima Bench by some geologists. The lithology of the site is dark gray to muddy black sandstone with a piece of wood and mud flakes. The site is currently observable in a gap in the pier.

3) Ks2005; The uppermost Hiraiga Formation. Although the site was regarded previously to belong to the Tanohata Formation (Obata and Matsukawa, 2018), that assignment is corrected here. The site is beneath the sea surface in the fishing port. Rock blocks bearing ammonite specimens were hauled out from the site during port renovations. The lithology is a black, well sorted siltstone.

4) OH5; The Sakiyama Formation. The site is on the Ebisudana Island and consists of brownish dark gray muddy sandstone. Ammonite and gastropod specimens were collected from the site by Dr. I. Obata. When Shimizu (1931, p. 7) described the specimen identified as *Acanthoplites subcornuerianus* from this locality, he noted that the specimen was obtained from 20 m below the layer yielding the specimen identified as *Parahoplites yaegashii*. There is a thickness of 20 m between the layers that yield *A. subcornuerianus* and *P. yaegashii*. Judging from this layer thickness difference, the layers that yield the specimens of *A. subcornuerianus* and *P. yaegashii* correspond to be located at loc. OH 4 and loc. OH 5, respectively. *Acanthoplites subcornuerianus* Shimizu, 1931, was named as *Hypacanthoplites subcornuerianus* (Hanai *et al*., 1968), and *P. yaegashii* Shimizu, 1931, was revised to *Nolaniceras*? *yaegashii* by Obata and Matsukawa (2018, p. 259–261, figs. 33A–D). Hn2051, Hy2099 and Kc–e are probably the same as this location.

5) Locs. 1, 2 and 3; These sites are described by Inose *et al*. (2013) and are located on Ebisudana Island, in the Sakiyama Formation. Ammonite specimens are found at the locations Locs. 1 and 2 in Facies 1, and at location Loc. 3 in Facies 2, which overlies the Facies 1. Specimen of Desmoceratidae gen. *et* sp. indet. from the location Loc. 3 is listed in Inose *et al*. (2013), but we have not seen the specimen. The stratigraphic relationship between locality OH5 and localities Locs. 1, 2 and 3 is unknown.

SYSTEMATIC PALEONTOLOGY

A total of 45 ammonite specimens from the Miyako Group in the Sakiyama region were used in the paleontological systematics of this study. Species listed in other published papers, e.g., Toshimitsu and Hirano (2000), are excluded from the study as most of them lack paleontological descriptions and photographs.

1) Repositories of Specimens

The specimens described the present paper are kept in the following institutions.

IGPS: The Tohoku University Museum, Sendai, Miyagi Prefecture

NMNS: The National Museum of Nature and Science, Tsukuba, Ibaraki Prefecture

TGUSE: Tokyo Gakugei University, Tokyo

2) Conventions

Higher systematic nomenclature follows the Treatise (Wright *et al*., 1996), except for the systematic nomenclature of the order Ammonitida, which follows that of Hoffmann *et al*. (2022). Morphological terms used are defined in the Treatise (Arkell *et al*., 1957) and descriptive terms (e.g., very small, very large, fairly narrow, and others) are those of Matsumoto *et al*. (1988). The following symbols for measurements are used; D = the total diameter; U = the diameter of umbilicus; U/D = the umbilicus/total diameter ratio; H = the whorl height; W = the whorl width; W/H = the width/height ratio; L = the maximum length of shaft; B = the maximum breadth of contiguous shafts; T = maximum thickness of contiguous shafts; w1 = the width of earlier shaft; h1 = the height of earlier shaft; w2 = the width of later shaft; h2 = the height of later shaft; w1/h1 = the width of earlier shaft/ the height of earlier shaft ratio; w2/h2 = the width of later shaft/the height of later shaft ratio. All measurements are given in mm, unless otherwise stated.

3) Ammonites

Order Ammonitida Haeckel, 1866
Suborder Lytoceratina Hyatt, 1889
Superfamily Lytoceratacеae Neumayr, 1875
Family Lytoceratidae Neumayr, 1875
Subfamily Lytoceratinae Neumayr, 1875
Genus *Pictetia* Uhlig, 1883

Pictetia sp.

Figs. 5A-D

2013 *Pictetia* sp., Inose *et al*., figs.5–9.

Material. A single specimen, NMNS-PM 23798 (Inose *et al*. collectors), is a part of the early shell, and comes from location Loc. 2, Ebisudana, Hideshima coast, Miyako City.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	H	W	W/H
NMNS-PM 23798	---	---	---	4.0	3.8	0.95

Descriptive remarks. The specimen is characterized by a loosely coiled whorl that is circular in section, with rapid expansion rate. Surface is ornamented with feeble ribs on flanks which disappear on venter and dorsum, and also with constrictions forming a faint groove. The characteristics of the constrictions of the present specimen are similar to those of the specimens identified as *Pictetia* aff. *astieriana* (Obata and Matsukawa, 2018). Although the small size and preservation of the specimen precludes determination that the whorls were not in contact, the overall whorl shape allows us to assign to the specimen to *Pictetia* sp.

Occurrence. The genus is reported from the lower and middle Albian of western Europe, Transcaspia, India, Madagascar, Zululand; Collignon (1962) has recorded two species from the upper Aptian of Madagascar (Kennedy and Klinger, 1978), Albian of Bulgaria (Ivanov, 1993) and Japan (Obata, 1967). The genus has also been recorded from western North America at Haida Gwaii (Haggart, 1986) and northern California (Rodda and Murphy, 1992), and from western South America (Riccardi and Medina, 2002).

Superfamily Tetragonitaceae Hyatt, 1900
Family Gaudryceratidae Spath, 1927
Genus *Eogaudryceras* Spath, 1927
Subgenus *Eotetragonites* Breistroffer, 1947

Eogaudryceras (*Eotetragonites*) sp.

Figs. 5E–H

2013 *Eotetragonites* sp., Inose *et al*., Figs. 5–5a, b.

Material. A single specimen, NMNS-PM 23794 (Inose *et al*. collectors), is shell, and comes from the Sakiyama Formation at location Loc. 2, Ebisudana, Hideshima

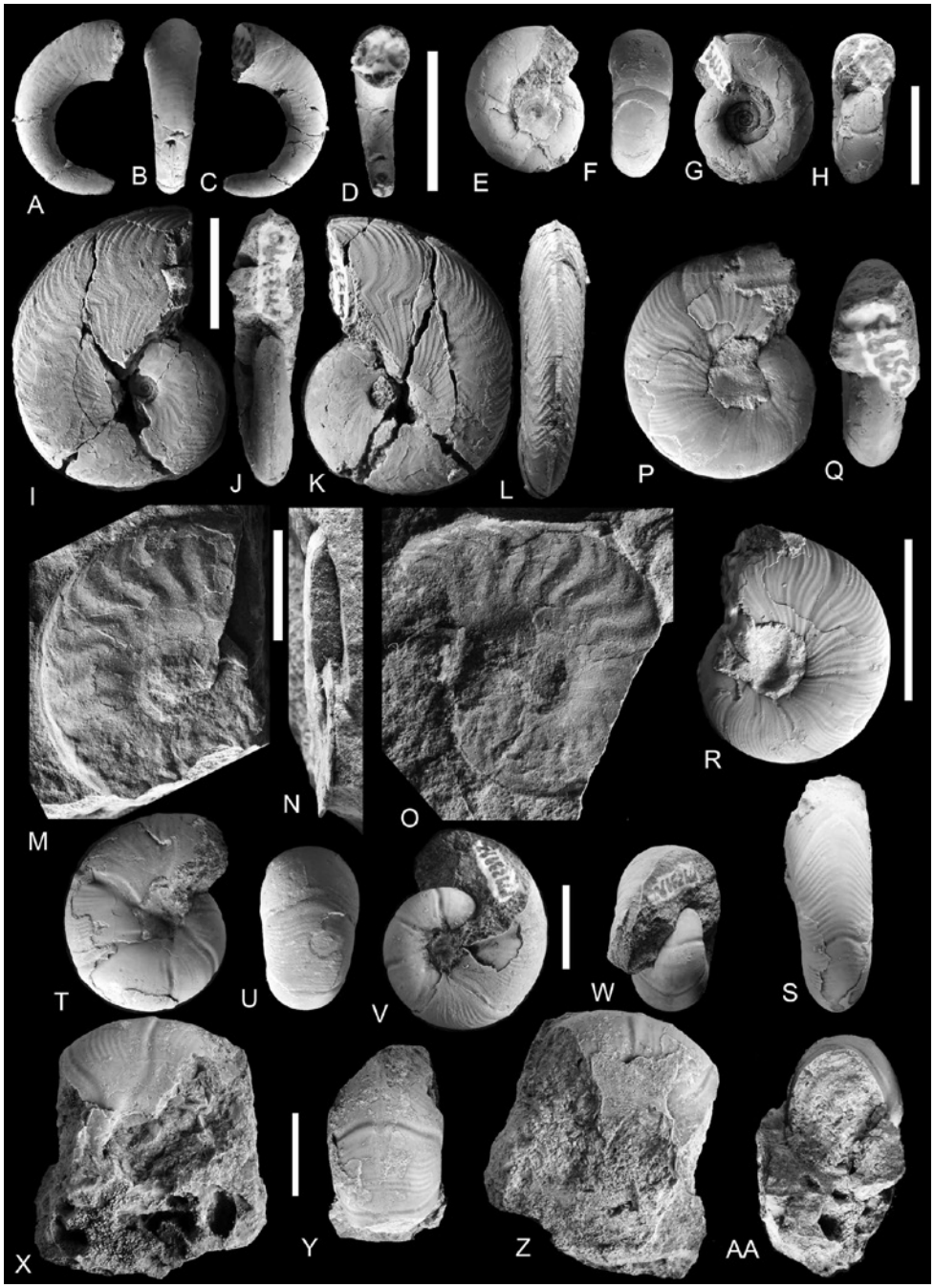

Fig. 5 A-D, *Pictetia* sp.; NMNS-PM 23798 (Inose *et al*. collectors), shell, Sakiyama Formation (loc. Loc. 2), lateral (A and C), ventral (B) and frontal (D) views. E-H, *Eogaudryceras* (*Eotetragonites*) sp.; NMNS-PM 23794 (Inose *et al*., collectors), shall, Sakiyama Formation (loc. Loc. 2), lateral (E and G), ventral (F) and frontal (H) views. I-L, *Aconeceras* aff. *nisoides*; NMNS-PM 23790 (Inose *et al*. collectors), shell, Sakiyama Formation (loc. Loc. 1), lateral (I and K), ventral (L) and frontal (J) views. M-O, *Sanmartinoceras bifurcatum*; TGUSE-MM 6101 (K. Tanaka collector), shell, Hiraiga Formation (loc. Ob01), lateral (M), frontal (N) and external mold of lateral (O) views. P-S., *Anadesmoceras* sp.; NMNS-PM 23793 (Inose *et al*. collectors), shell, Sakiyama Formation (loc. Loc. 2), lateral (P and R), ventral (S) and frontal (Q) views. T-AA, *Valdedorsella kasei*; T-W, NMNS-PM 23792, Sakiyama Formation (loc. Loc. 2), lateral (T and V), ventral (U) and frontal (W) views, X-AA, TGUSE-MM 6413 (I. Obata collector), shell, Hiraiga Formation (loc. OH5), lateral (X and Z), ventral (Y) and frontal (AA) views. Scale bars show 1 cm.

coast, Miyako City.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	W	H	W/H
NMNS-PM 23794	15.4	6.5	0.42	6.5	6.0	1.08

Description. Shell is very small with moderate umbilicus. Whorl is fairly evolute, fairly depressed, with round flanks in younger growth stage which flatten in later stage. The whorl is subquadrate in section, becoming rounded on venter. Surface is ornamented with smooth and faint lirae, and strong, wide and shallow constrictions which number four on the last volution of the whorl. Constrictions are prorsiradiate and weakly convex, cross the venter in a weakly forward orientation, and are accompanied with weak collars on the forward side in later whorls.

Remarks. The fairly depressed subquadrate whorl and its smooth surface with strong constrictions suggest to us that the specimen most likely belongs to the genus *Eogaudryceras* (*Eotetragonites*) (Wright *et al*., 1996). However, there is a possibility that the specimen belongs to the genus *Anagaudryceras* because the last constriction has a collar.

Comparison. The specimen differs from the specimens of *Eogaudryceras* (*Eotetragonites*) *antiqua* (Obata and Matsukawa, 2009, pp. 99–101, figs. 3E–F, G–J, N–P, Q–T, U–V, W–Y, Z1-3, AA1-2) from the Barremian Kimigahama Formation of the Choshi Group, because the constrictions on the last volution of the present specimen number four, whereas the specimens from the Choshi Group exhibit fewer constrictions. The present specimen is different from the illustrated specimens identified as *Eotetragonites wintunius* (Murphy, 1967, pp. 20–21, figs. 4, 5, 6) from the middle and upper parts of the E. *wintunius* Zone, corresponding to the Aptian in northern California, because the number of constrictions per last whorl is four in the present specimen, but more than 10 in the Californian specimens.

Occurrence. The genus is reported from the Aptian and Albian of Spain (Wiedmann, 1962), France (Breistroffer, 1947), Bulgaria (Ivanov, 1993), Romania (Avram *et al*., 1990), the Northern Caucasus (Drushchits, 1956), the western Caucasus (Egoian, 1969), California (Anderson, 1938), Madagascar (Collignon, 1956), Algeria (Wiedmann, 1962), and Japan (Obata and Futakami, 1992).

Superfamily Haploceratacеae Zittel, 1884

Family Oppeliidae H. Douvillé, 1890

Remarks. Casey (1961) and Kennedy and Klinger (1979) classified the genus *Aconeceras* within the family Aconeceratidae. Subsequently, Wright *et al*. (1996) placed the genus within the family Oppeliidae. We follow the classification of Wright *et al*. (1996).

Subfamily Aconeceratinae Spath, 1923

Remarks. Within family Oppeliidae, Wright et al. (1996) recognized the family Oppeliidae into the subfamily Aconeceratinae, containing the genus *Aconeceras*; We follow this subfamily classification of Wright *et al*. (1996).

Genus *Aconeceras* Hyatt, 1903

Aconeceras aff. *nisoides* (Sarasin, 1893)

Figs. 5I–L

Synonymy.

2013 *Aconeceras* (*A*.) cf. *nisus*, Inose *et al*., fig. 5–1a, b.

2018 *Aconeceras* (*A*.) cf. *nisus*, Obata and Matsukawa, p. 241, = Inose *et al*., fig. 5–1a, b.

Compare.

1893 *Oppella Nisoides* Sarasin, pp. 155–156, pl. 4–6, fig. 5; 10a, b, c.

2000 *Sanmartinoceras* aff. *walshense*, Lehmann and Murphy, p. 119-124, figs. 2, 3.

Material. A single specimen, NMNS-PM 23790 (Inose *et al*. collectors), is complete shell, and comes from the Sakiyama Formation at location Loc. 1, Ebisudana, Hideshima coast, Miyako City.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	W	H	W/H
NMNS-PM 23790	24.2	3.2	0.13	6.6	16.0	0.41

Description. Shell is small oxycone. The width of the umbilicus is narrow. The whorl is high, strongly compressed, very involute, and fastigate in section with subparallel, feebly convex flanks, angular ventral shoulder, and a keel in the center of the flat venter. The keel is finely serrated and low. The umbilicus is deep, its

wall is steep and vertical, and its shoulder forms a right angle. The flank of surface is ornamented with dense sickle-like ribs consisting of falcate primaries and concave secondaries. The curvature of the ribs on the outer flanks, which corresponds to the blade of sickle, is weak in the earlier whorls but strengthens in later one (Fig. 6). The ribs are feeble in earlier whorls, but strengthen and become crowded on later whorl with minor ribs appearing on later whorls. The primary ribs arise at the umbilical margin and are rather coarse in the early whorl; they curve forward slightly on the lower flank, turn backwards through about 90 degrees at the middle flank, and form a circular pattern on the outer flanks. The secondary ribs arise at the outer flanks on the later whorl and are inserted irregularly between two primaries; these ribs become denser and project forward on the venter, but are interrupted at the keel. Suture-line is fairly simple; the ventral lobe is shallow. lateral lobes are rather deep, trifid and symmetrical, lateral saddles are symmetrical (Fig. 7).

Remarks. The specimen is similar to the illustrated specimen of *Oppella Nisoides* (Sarasin, 1893, pp. 155–156, pl. 6, fig. 10c), type specimen of the species, from the lower Aptian of France, in having dense sickle-like ribs that are feeble on the early whorl, and strengthen and become crowded on later whorl. However, the present specimen differs from the French specimen in that its keel is higher than that of the French specimen, and the French specimen has a dent-like spiral depression on the flanks, although this is not recognized in Sarasin's description, whereas the present specimen lacks this feature. The suture-line of the present specimen is also different from that of the French specimen: that of the present specimen is fairly simple whereas the pattern on the French specimen is dissected. The simple characteristics of the lateral saddle of the present specimen are similar to those of the 4th, 5th and 6th lateral saddles of the French specimen, and the shallow ventral lobe and deep 1st lateral lobe of the present specimen are similar to these of the French specimen.

The present specimen is identified as an ally of *A*.

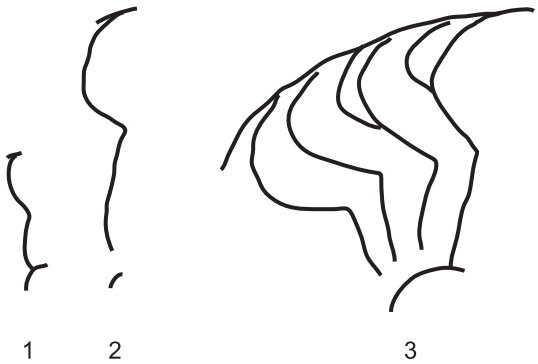

Fig. 6 Rib pattern of *Aconeceras* aff. *nisoides* (NMS-PM 23790) (1 and 2) and *Sanmartinoceras bifurcatum* (TGUSE-MM 6101) (3).

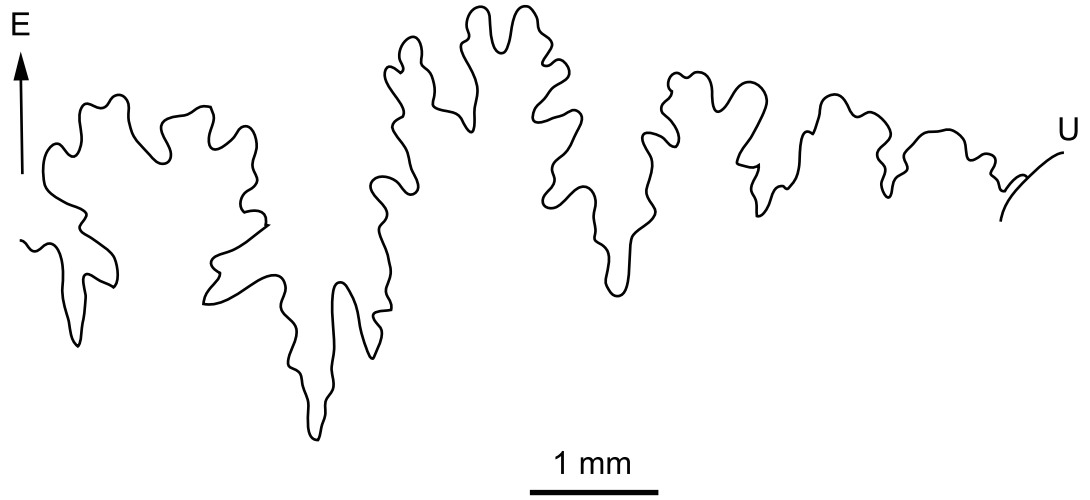

Fig. 7 Suture-line of *Aconeceras* aff. *nisoides* (NMS-PM 23790).

nisoides because the change in the ribbing that accompanies growth of the present specimen is similar to that seen on the French specimen.

The present specimen differs from the illustrated specimen of *Ammonites nisus* (Orbigny, 1840, p. 184, p. 55, figs. 7–9), type specimen of the species, from the upper Aptian of southeast France, because the surface of the French specimen is smoother than that of the present specimen. The pattern of sickle-like ribs on the Japanese specimen is similar to that of the specimen identified as *S.* aff. *walshense* (Lehmann and Murphy, 2000), probably from the upper Aptian in California, but the ribs of the present specimen are more distinct than these of the Californian specimen. As well, the California specimen has a slight spiral depression on the last septate whorl, which suggests that it belongs to the genus *Sanmartinoceras*, whereas the Japanese specimen lack this depression.

Occurrence. The genus is reported from the Aptian and Albian, England (Casey, 1961), France (Orbigny, 1840), Germany (Kemper, 1964), Bulgaria (Dimitrova, 1967), Colombia (Etayo-Serna, 1979), Antarctica (Thomson, 1974), as well as at the Jurassic – Cretaceous boundary in Tibet (Liu, 1988).

Genus *Sanmartinoceras* Bonarelli in Bonarelli and Nágera, 1921

Remarks. Casey (1961) defined the genus *Sanmartinoceras* for stout-whorled Aconeceratidae with falciform striae turning into strong costae, a high and serrated keel, and a prominent spiral depression. We follow his definition of the genus.

Sanmartinoceras bifurcatum sp. nov.
Figs. 5M–O, 9P

Material. A single specimen, TGUSE-MM 6101 (holotype) (K. Tanaka collector), comes from black mudstone of the Hiraiga Formation, at location Ob01, in Hideshima fishing port, Miyako City, Iwate Prefecture. The outer part of the right lower shell is lost.

Derivation of name. *Sanmartinoceras* with bifurcated ribs.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	W	H	W/H
TGUSE-MM 6101 (holotype)	25.4	ca. 4.8	ca. 0.19	2.7	10.5	0.26

Description. Shell is small oxycone with narrow umbilicus. Whorl is fairly evolute (36%), much compressed (26%), with a lateral depression on inner flanks of the earlier whorl, flattened flanks, with its widest point at about one-third of the flank distance from the umbilical margin. The whorl is subelliptical in section, gradually converging to a fastigate venter with angular ventral shoulder. Keel is finely indistinct, serrated, and low. Flank surface is ornamented with sickle-like ribs, which are weak on the lower flank but strengthen on the middle and outer flanks. Eleven ribs are counted in a half volution. They arise at the lower flank, trend straight radially on the lower flank, bend strongly backward on the middle flank, then bend rounded forward on the outer flanks and trend forward strongly on the ventrolateral shoulder, although they are interrupted in the ventral center. The ribs on later whorls branch into two on the outer flank (Fig. 6).

Remarks. Because of oxyconic whorl with fastigate venter, serrated keel, lateral depression in the earlier whorl, and strengthening ribs on the outer flank (Casey, 1961), the specimen is identified as the genus *Sanmartinoceras*. Although Kennedy and Klinger (1979) defined the type species of the genus *Sanmartinoceras* as *S. patagonicum* Bonarelli (1921, p. 27, pl. 5, figs. 3–5), from the Kachaike Formation of Lago San Martin, Santa Cruz, Argentina, which is characterized by periodic bunched ribs, they did not describe that the ribs bifurcate on the outer flank. The present specimen is different from the illustrated specimens of *S. patagonicum* (Riccardi *et al*., 1987, pp. 134–137, pl. 3, figs. 5–11) from the Albian of Patagonia in Argentina, because the keel of the Patagonian specimens is higher than that of the present specimen, and the ribs of the Patagonian specimens are not bifid, whereas those of the present specimen are bifid. Since the branching of ribs on the outer whorl into two at the outer flank is a unique characteristic of the Japanese specimen that is not confirmed in any other species attributed to the genus *Sanmartinoceras*, we consider it to be a new species.

Occurrence. The genus ranges from Barremian to Albian, and is reported from Germany (von Koenen,

1902), California (Lehmann and Murphy, 2000), Argentina (Riccardi *et al*., 1987), Australia (Whitehouse, 1926), Zululand (Kennedy and Klinger, 1979), Antarctica (Thomson, 1974), and Japan (this paper).

Superfamily Desmoceratacеae Zittel, 1895
Family Desmoceratidae Zittel, 1895
Subfamily Puzosiinae Spath, 1922
Genus *Valdedorsella* Breistroffer, 1947

Valdedorsella kasei Obata and Matsukawa, 2018
Figs. 5T–AA

2013 *Valdedorsella getulina*, Inose *et al*., fig. 5–3.

2018 *Valdedorsella kasei* Obata and Matsukawa, p. 241, figs. 15A–T.

Material. Two specimens, TGUSE-MM 6413 (I. Obata collector), a part of outer whorl, from location OH5; NMNS-PM 23792 (Inose *et al*. collectors), shell, from location Loc. 2. Both specimens come from the Sakiyama Formation, Ebisudana, Hideshima coast, Sakiyama region, Miyako City.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	W	H	W/H
TGUSE-MM 6413	---	7.1	---	14.9	12.1	1.23
NMNS-PM 23792	21.0	4.6	0.22	12.5	10.5	1.19

Descriptive remarks. Because of its small shell, depressed and infalted whorl (W/H ranges from 1.19 to 1.23) with broad and rounded venter, convexly curved ribs and constrictions, the specimens are identified as *Valdedorsella kasei* (Obata and Matsukawa, 2018, p. 241, figs. 15A–T) from the Miyako Group. To date, six specimens of this species have been reported by Obata and Matsukawa (2018); (1) NMNS-PM 35072, the holotype of the species from Ks2005, (2) and (3) NMNS-PM 35073 and 35074 from locality Kc-e, Ebisudana, Hideshima coast, (4) NMNS-PM 35075 from locality Hy2099, Ebisudana, (5) and (6) NMNS-PM 35076 and NMMS-PM 35077 from Ks3001, Taro. The specimens of the present study are thus the seventh and eighth specimens from the Hideshima coast in Sakiyama region.

Occurrence. The genus is reported from Spain (Fallot, 1920), France (Jacob, 1905), Poland (Vašíček, 1973), Slovakia (Vašíček et al., 1994), Bulgaria (Dimitrova, 1967), Romania (Avram, 1995), Crimea, Ukraine (Karakasch, 1907), Alaska, U.S.A. (Imlay, 1960), Colombia (Bogdanova and Hoedemaeker, 2004), Argentina (Aguirre-Urreta *et al*., 2005), and Japan (Obata, 1967).

Family Kossmaticeratidae Spath, 1922
Subfamily Marshallitinae Matsumoto, 1955
Genus *Marshallites* Matsumoto, 1955

Marshallites miyakoensis Obata and Futakami, 1991
Figs. 8A, B, G-I

1991 *Marshallites miyakoensis* Obata and Futakami, pp. 124–128, pl. 31, figs. 1–5.

2013 *Pseudohaploceras* sp., Inose *et al*., fig. 6a, b.

2018 *Marshallites miyakoensis*, Obata and Matsukawa, figs. 35E–I.

Material. Three specimens. (1) NMNS-PM 23795 (Inose *et al*. collectors) is complete shell and comes from the Sakiyama Formation at location Loc. 1, Ebisudana, Hideshima coast, Miyako City. Two fragmentary specimens, (2) TGUSE-MM 6212 (I. Obata collector), an internal mold, from the Hiraiga Formation at location OH4, at Hideshima fishing port and (3) TGUSE-MM 6419 (I. Obata collector), an external mold, from the Hiraiga Formation at location Ob01, Hideshima fishing port, Miyako City.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	W	H	W/H
NMNS-PM 23795	30.5	8.2	0.27	8.8	13.9	0.63
-1/4 phi	24.5	6.2	0.25	6.5	12.0	0.54
TGUSE-MM 6212	31.7	8.6	0.27	---	12.7	---
TGUSE-MM 6419	---	---	---	---	2.3	---

Descriptive remarks. Because of its fairly small, compressed whorl, narrow umbilicus, flexuous ribs which branch at the umbilical margin and on the mid-flanks, and its narrow and deep constrictions which are parallel with ribs, the specimen is identified as *Marshallites miyakoensis* Obata and Futakami, 1991. The illustrated specimen of *Pseudohaploceras* sp. (NMNS PM 23795) of Inose *et al*. (2013, figs. 5–6a, b) from the Sakiyama Formation at location Loc. 1 can be identified as the present species based on its ribs bundled at the umbilical margin, some of them bifurcated into two on the middle

flank, and also the constrictions parallel with ribs.

Occurrence. The genus is reported from the Aptian of the Philippines (Matsukawa *et al*., 2012), the Aptian of Kumamoto, Japan (Matsumoto *et al*., 1968; Matsumoto and Murakami, 1991) and the Aptian of Miyako (Obata and Futakami, 1991), the Cenomanian of Hokkaido (Matsumoto *et al*., 1991), the Albian – Cenomanian of western Korjak and Kamchatka (Alabushev, 1995), the Cenomanian of Alaska (Matsumoto, 1959), and the Albian of British Colombia, Canada (Haggart, 1986, 1991).

Family Cleoniceratidae Whitehouse, 1926
Genus *Anadesmoceras* Casey, 1954

Anadesmoceras sp.
Figs. 5P–S

2013 Desmoceratidae gen. *et* sp. indet., Inose *et al*., fig. 4a, 4b.

Material. A single specimen, NMNS-PM 23793 (Inose *et al*. collectors) is shell, and comes from the Sakiyama Formation at location Loc. 2, Ebisudana, Hideshima coast, Miyako City.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	W	H	W/H
NMNS-PM 23793	14.0	ca.3.6	ca.0.26	5.2	ca.6.7	ca.0.78

Descriptive remarks. The specimen is characterized by a thick whorl ornamented with sigmoid ribs, some of them bundled, and with distinct and comparatively deep constrictions which are parallel to ribs. The specimen is similar to the illustrated specimen of *Carloscaceresiceras caceresi* (Etayo-Serna, 1979, p. 25, pl. 10, fig. 1; text-figs. 4A, B; 10), which is characterized by a lack of ribs on the inner lateral area. However, the characteristics of the present specimen cannot be fully confirmed due to adhering matrix.

Regarding the genus *Carloscaceresiceras*, there are two diverse opinions; Wright *et al*. (1996) and Klein and Vašíček (2011) consider the genus as a junior synonym of the genus *Anadesmoceras*, while Bogdanova and Hoedemaeker (2004) consider it to be distinguishable from the genus *Anadesmoceras*. González-León *et al*., (2016) demonstrated a specimen from the lower Albian of Colombia as *Carloscaceresiceras* cf. *caceresi*. Although they did not describe its systematic description, they mentioned the genus is valid. We are not able to assess this argument because we have only one small specimen available, which we identify the specimen as *Anadesmoceras* sp.

Occurrence. The genus is reported from the lower Albian of England (Casey, 1966), Mangyshlak (Kazakhstan) (Saveliev, 1973), Colombia (Etayo-Serna, 1979) and Japan (this paper).

Suborder Ancyloceratina Wiedmann, 1966
Superfamily Ancyloceratacеae Gill, 1871
Family Ptychoceratidae Gill, 1871
Genus *Ptychoceras* Orbigny, 1840

Ptychoceras cf. *emericianum* Orbigny, 1840
Figs. 8C–F

2013 *Ptychoceras* sp., Inose *et al*., figs. 5–10.

Material. A single specimen, NMNS-PM 23799 (Inose *et al*. collectors), a partial specimen consisting of two contiguous shafts. The specimen comes from the Sakiyama Formation at location Loc. 2.

Dimension (in mm except for w1/h1 and w2/h2).

Specimen	L	B	T	w1	h1	w1/h1	w2	h2	w2/h2
NMNS-PM 23799	10.2	3.2	2.2	1.4	1.5	0.93	2.0	1.5	1.33

Descriptive remarks. The specimen is so small for the genus, and is characterized by contiguous shafts, smooth on the surface of the early shaft, with ribs appearing on the later shaft. The ribs consist of those that rise at the dorsum seam and those which appear on the upper flank. The section of the shaft is circular and becomes wider than high. These characteristics suggest that the specimen can be identified as *Ptychoceras emericianum* (Orbigny, 1840, p. 555, pl. 137, figs. 1–4), from the Aptian of southeast France, although the French specimens are larger than the present specimen. Since the ontogenetic characteristics of both specimens are unknown, we identify the present specimen as *Ptychoceras* cf. *emericianum* (Orbigny, 1840).

Occurrence. *Ptychoceras emericianum* is reported from France (Orbigny, 1840), Romania (Avram, 1970), and the northern Caucasus (Rouchadzé, 1938).

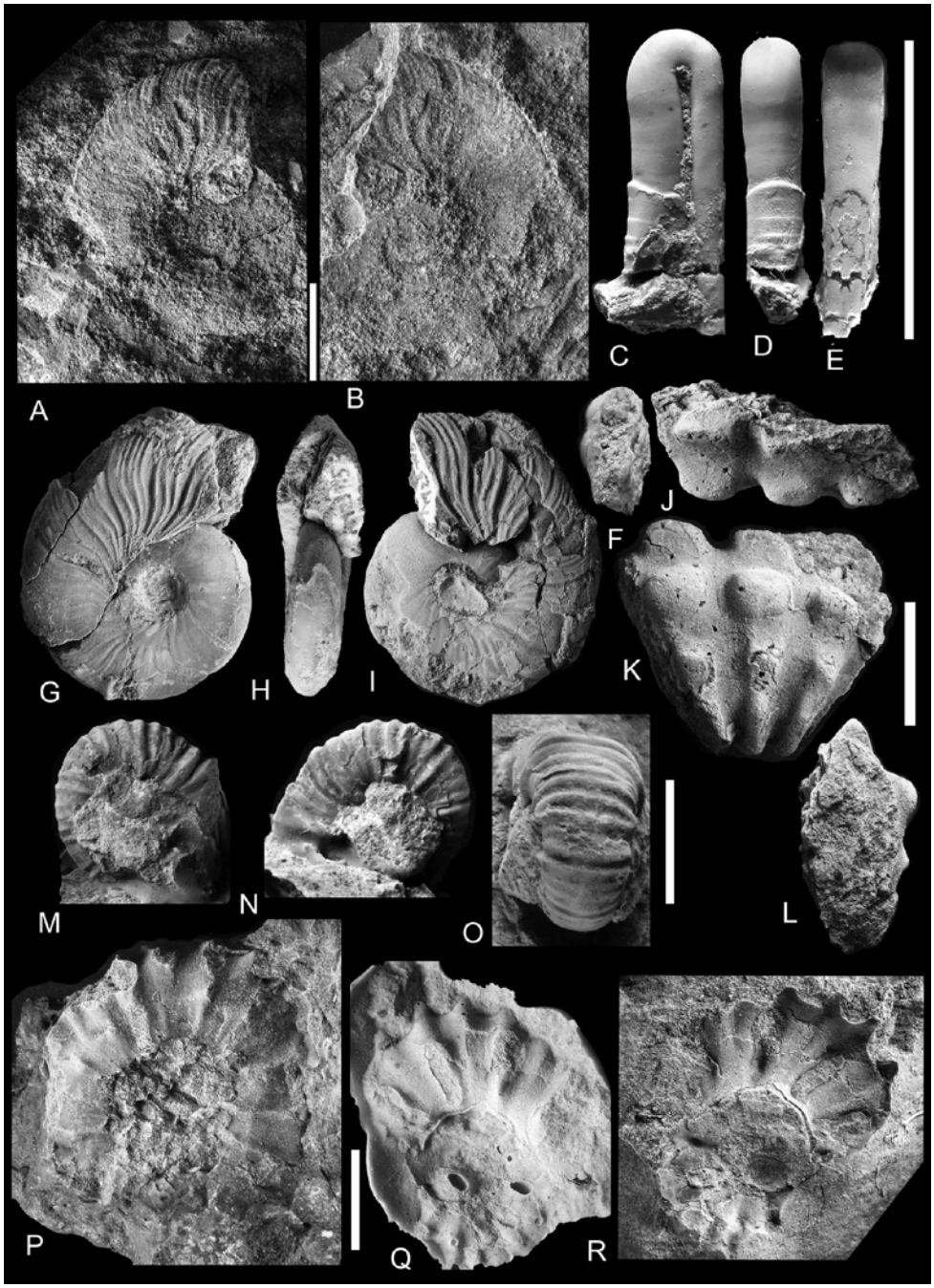

Fig. 8 A-B, G-I, *Marshallites miyakoensis*; A, TGUSE-MM 6212 (I. Obata collector), lateral view of internal mold of whorl, Hiraiga Formation (loc. OH4, B, TGUSE-MM 6419 (I. Obata collector), external mold of whorl, Hiraiga Formation (loc. Ob01), G-I, NMNS-PM 23795 (Inose *et al*. collectors), shell, Sakiyama Formation, lateral (G and I) and frontal views. C-F, *Ptychoceras* cf. *emericianum*; NMNS-PM 23799 (Inose *et al*. collectors), shell, Sakiyama Formation (loc. Loc. 2), lateral (C), ventral (D and E) and frontal (F) views. J-L, *Paracheloniceras guenoti*; IGPS 36512B (S. Shimizu collector), an internal mold of a partial whorl, Hiraiga Formation (loc. OH4), lateral (K), ventral (J) and frontal (L) views. M-O, *Epicheloniceras* sp.; TGUSE-MM 6416 (S. Nagashima collector), shell, Hiraiga Formation (loc. OH4), lateral (M, N), and ventral (O) views. P-R, *Diadochoceras nodosocostatiforme*; L, IPMM 31210 (F. Sasaki collector), Hiraiga Formation (loc. Ks 2005), lateral view, Q and R, TGUSE-MM 6421 (T. Kase collector), (loc. Ks2005), external mold (R) and its rubber pull (Q). Scale bars show 1 cm.

Superfamily Douvilleiceratacеae Parona and Bonarelli, 1897

Family Douvilleiceratidae Parona and Bonarelli, 1897

Subfamily Cheloniceratinae Spath, 1923

Genus *Epicheloniceras* Casey, 1954

Epicheloniceras sp.

Figs. 8M–O

Material. Two specimens, TGUSE-MM 6416 (S. Nagashima collector) and TGUSE-MM 6431 (I. Obata collector), from dark gray mudstone of the Hiraiga Formation at location OH4, Hideshima fishing port, Miyako City.

Dimension (in mm except for W/H).

Specimen	D	U	U/D	W	H	W/H
TGUSE-MM 6416	15.2	---	---	8.3	7.9	1.05

Descriptive remarks. The specimens are characterized by small shell, depressed whorl (W/H of TGUSE-MM 6416: 1.05), and dense and radiate ribs. These consist of major and minor ribs, with two or three minor ribs sandwiched between major ribs on the early whorl, and with one rib sandwiched between major ribs and / or only the major ribs on the later whorl. Some major ribs have a lateral tubercle and a ventrolateral projection lacking a protruding tubercle, and branch into two at the lateral tubercle. Based on these characteristics, and the fact that the specimen are about 15 mm in diameter, they can be identified as the genus *Epicheloniceras* (Wright *et al*., 1996). Since there are no other, more mature specimens in the Hideshima area which can be identified as *Epicheloniceras* in the area, we therefore identify the specimens as *Epicheloniceras* sp.

Occurrence. The genus is reported from England (e.g. Casey, 1962), Spain (e.g. Moreno-Bedmar *et al*., 2012), France (e.g. Ropolo *et al*., 2008), Germany (e.g. Kemper, 1963), Switzerland (e.g. Jacob and Tobler, 1906), Italy (Tavani, 1949), Bulgaria (Dimitrova, 1967), Russia (e.g. Wassiliewski, 1908), the Caucasus (e.g. Sinzow, 1907), Georgia (e.g. Eristavi, 1955), Dagestan (e.g. Rouchadzé, 1938), California (Anderson, 1938), Mexico (e.g. Humphrey, 1949), Colombia (e.g. Etayo-Serna, 1979), Madagascar (e.g. Collignon, 1962), Mozambique (Förster, 1975) and Japan (e.g. Matsukawa, 2021).

Genus *Parachelonicerаs* Collignon, 1962

Parachelonicerаs guenoti Collignon, 1965

Figs. 8J–L

1965 *Parachelonicerаs guenoti* Collignon, pl. 1, figs. 1, 1a, 1b, 2, 2a, b.

2000 *Parachelonicerаs guenoti*, Kennedy, fig. 58de, e = Collignon, 1965, pl. 1, figs. 2, 2a, 2b.

Material. A single specimen, a partial whorl of an internal mold, IGPS36512B (S. Shimizu collector), with piece of shell, from a dark gray to black muddy sandstone bed that corresponds to the Hiraiga Formation at location OH4, Hideshima fishing port, Miyako City.

Dimension (in mm except for W/H).

Specimen	D	U	U/D	W	H	W/H
IGPS36512B	---	---	---	---	15.7	---

Descriptive remarks. The specimen is characterized by an elliptical whorl with coarse, broad, radiate, straight and flat-topped ribs that broaden across the flanks. The ribs have weak umbilical bullae, a small inner lateral tubercle, large outer tubercles, and large ventrolateral clavi. Based on the features, the specimen is identified as *Parachelonicerаs guenoti* (Collignon, 1965, pp. 47–48, pl. 1, figs. 1a, b, 2a, b), from the Aptian of Madagascar. The surface ornamentation of *P. guenoti* from Aptian Madagascar is almost the same throughout growth. Therefore, even though the present specimen is a partial whorl fragment, we judged that its characteristics are the same as the illustrated specimens of *Parachelonicerаs guenoti* (Collignon, 1965, pp. 47–48, pl. 1, figs. 1a, b, 2a, b).

Occurrence. The species is reported from the upper Aptian of Madagascar (Collignon, 1965).

Genus *Diadochoceras* Hyatt, 1900

Diadochoceras nodosocostatiforme (Shimizu, 1931)

Figs. 8P–R

Synonymy.

1931 *Douvilleiceras nodosocostatiforme* Shimizu, p. 35, pl. 1, figs. 6, 7.

1968 *Diadochoceras nodosocostatiforme*, Hanai *et al*., pl. 2, fig. 7.

1968 *Diadochoceras* cf. *nodosocostatiforme*, Matsumoto, 1968, pp. 141–143, pl. 2, fig. 1.

1975 *Diadochoceras nodosocostatiforme*, Obata, pp. 2-5, pl. 1, figs. 3–5, text-figs. 1, 2.

1979 *Diadochoceras nodosocostatiforme*, Kitamura *et al*., pl. 7, figs. 1, 4.

2018 *Diadochoceras nodosocostatiforme*, Obata and Matsukawa, figs. M–P.

2021 *Diadochoceras nodosocostatiforme*, Matsukawa, pp. 10-11, figs. 7N-R.

Material. Two specimens. On IPMM 31210 (F. Sasaki collector) only the shell on the right side of the whorl is preserved. TGUSE-MM 6421 (T. Kase collector) is a part of external mold of shell. The specimens come from the upper part of the Hiraiga Formation at location Ks2005.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	H	W	W/H
IPMM 31210	ca.30.2	8.2	ca.0.41	11.0	---	---
TGUSE-MM 6421	ca.26.5	8.4	ca.0.32	ca.14.9	---	---

Descriptive remarks. The specimens are characterized by a very small shell with evolute whorl, moderate umbilicus, flank surface ornamented with coarse, strongly radial primary ribs with small umbilical bullae, large ventrolateral tubercle and ventral tubercles, and narrow minor ribs. Based on these features, the specimen is identified as *Diadochoceras nodosocostatiforme* (Obata, 1975, pp. 2–5, pl. 1, figs. 3–5, text-figs. 1, 2) from the Hiraiga Formation of the Miyako Group.

Occurrence. The genus is reported from France (Orbigny, 1840), Hungary (Szives, 2007), Georgia (Kvantaliani, 1972), the northern Caucasus (Mikhailova, 1963), the western Caucasus (Egoian, 1965), Kazakhstan (Glazunova, 1953), Madagascar (Collignon, 1962), Venezuela (Renz, 1982) and Japan (Obata, 1975).

Genus *Sonoraceras* Samaniego-Pesqueira, Moreno-Bedmar and Álvarez-Sánchez, 2021

Sonoraceras? sp.
Figs. 9N–O

Compare.

2021 *Sonoraceras tepachensis* Samaniego-Pesqueira, Moreno-Bedmar and Álvarez-Sánchez, pp. 4–7, figs. 7B–E, 8A–E; figs. 9A1–3; appendix 3B–E.

2022 *Sonoraceras*? sp., Matsukawa and Oji, p.152–153, fig. 4O–Q.

Material. A single specimen, TGESE-MM 6428 (I. Obata collector), is an external mold of a partial whorl, and comes from the upper part of the Hiraiga Formation at location OH4, Hideshima fishing port.

Dimension (in mm).

Specimen	D	U	U/D	W	H	W/H
TGUSE-MM 6428	---	---	---	---	8.4	---

Descriptive remarks. The specimen is characterized by rectangular whorl-section with angular ventral shoulder and flat flanks, and dense ribs which arise at the umbilical margin, trend straight across the flank and cross the venter orthogonally. Small tubercles are seen on some ribs at about mid-flank, and at the ventral shoulder on all ribs. Based on its quadrate whorl-section, straight ribs crossing on the venter, and two rows of tubercles on ribs at the mid-flank and at the ventral shoulder, the specimen tentatively is assigned to the genus *Sonoraceras* (Samaniego-Pesqueira *et al*., 2021, pp. 4–7, figs. 7B–E, 8A-E; figs. 9A1–3; appendix 3B–E) from the upper Aptian of the Agua Salada Formation in northwestern Mexico. However, the ribs of the present specimen are denser than those of the Mexican one, and the whorl-section of the present specimen is rectangular, whereas that of the Mexican specimen is quadrangular. Therefore, we identify the specimen as *Sonoraceras*? sp.

Occurrence. The genus *Sonoraceras* is reported from the upper Aptian of northwestern Mexico (Samaniego-Pesqueira *et al*., 2021).

Subfamily Douvilleiceratinae Parona and Bonarelli, 1897

Genus *Eodouvilleiceras* Casey, 1961

Remarks. Latil (2011) regarded the genus *Eodouvilleiceras* (Casey, 1961) as a synonym of the genus *Douvilleiceras* Grossouvre (1894). Based on the ontogeny of some juvenile, primitive members of the *Douvilleiceras* by Jacob (1905), Latil (2011) mentioned that the genus *Eodouvilleiceras*, described for transitional morphologies from *Epicheloniceras* to *Douvilleiceras*, could only represent an ontogenetic stage of an early member of the genus *Douvilleiceras*. Obata and Matsukawa (2018) then suggested that the specimens

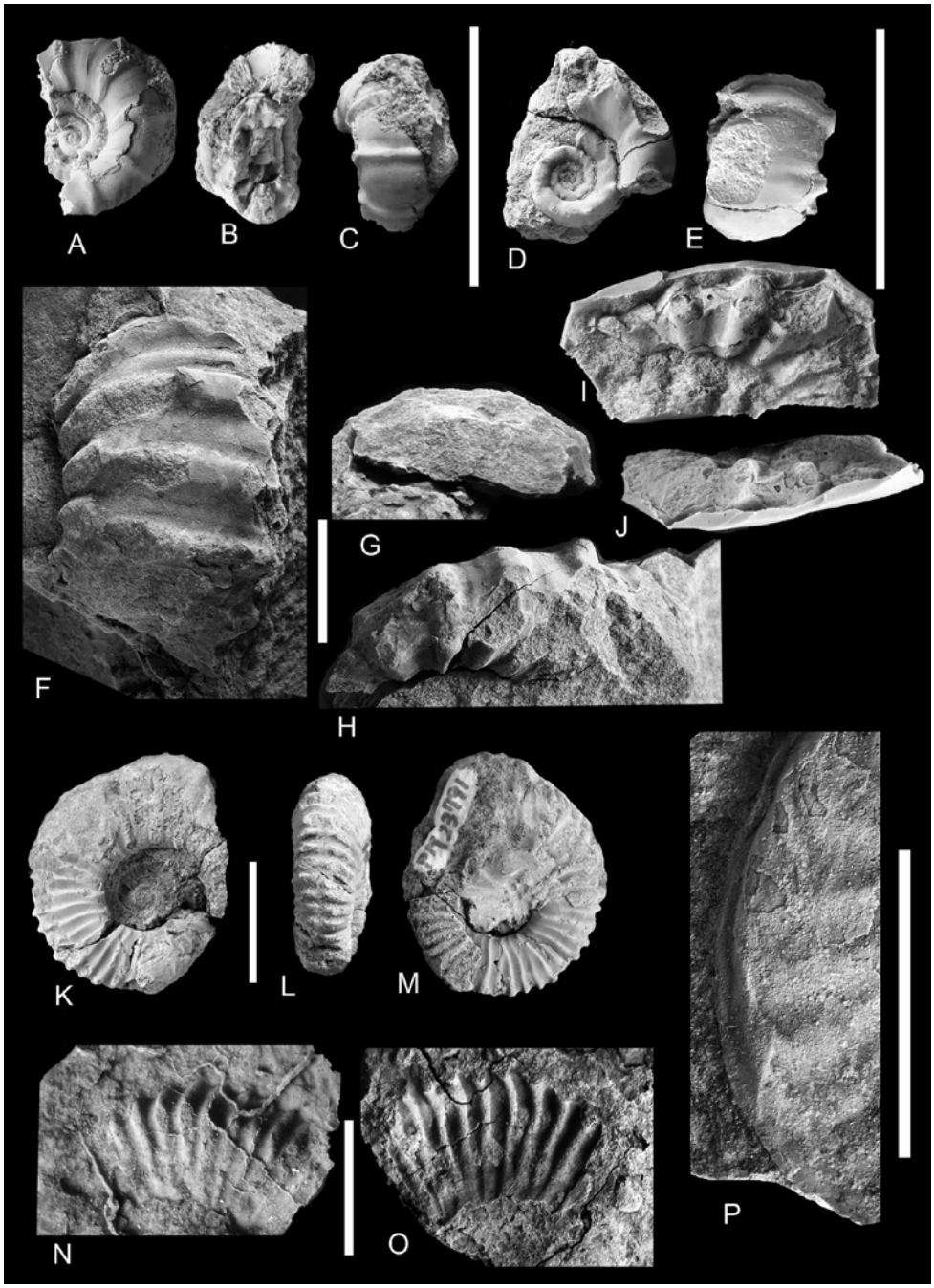

Fig. 9 A-J, *Eodouvilleiceras matsumotoi*; A-C, NMNS-PM 28796 (Inose *et al*. collectors), shell, Sakiyama Formation, (loc. Loc. 2), lateral (A), frontal (B) and ventral (C) views, D and E, NMNS-PM 23797 (Inose *et al*. collectors), shell, Sakiyama Formation (loc. Loc. 2), lateral (D) and ventral (E) views, F-J, TGUSE-MM 6174 (T. Kase collector), partial whorl of shell, ventral (F), frontal (G), lateral (H) views, and I and J (rubber pulls of lateral views). K-M, *Pseudoleymeriella hataii*, NMNS-PM 23791 (Inose *et al*. collectors), shell, Sakiyama Formation, (loc. Loc. 2), lateral (K and M) and ventral (L) views. N, O, *Sonoraceras*? sp., TGUSE-MM 6428 (I. Obata collector), Hiraiga Formation (loc. OH4), lateral view of external mold (O) and its rubber pull (N). P. *Sanmartinoceras bifurcatum*; TGUSE-MM 6101 (K. Tanaka collector), Hiraiga Formation (loc. Ob01), keel enlarged. Scale bars show 1 cm.

named as *Eodouvilleiceras matsumotoi* should be revised to *Douvilleiceras matsumotoi* because these specimens are characterized by morphologies characteristic of the genus *Epicheloniceras* in early stage, and by the genus *Douvilleiceras* in later stage, i.e., exhibiting a single ventrolateral tubercle on the rib in early growth stages and two ventrolateral tubercles on each rib in later stages. However, in those specimens, the characteristics of the genus *Epicheloniceras*, in which the ribs bifurcate into two at the lateral tubercles, is not recognized. This does not support the idea of Latil (2011). Therefore, some specimens identified as the genus *Eodouvilleiceras* do not show ontogenetic morphological changes from the genus *Epicheloniceras* to the genus *Douvilleiceras*, and they are appropriately to be identified as the genus *Eodouvilleiceras*. In conclusion, we follow the Obata's (1969) taxonomy that the specimens are identified as *Eodouvilleiceras matsumotoi*.

Eodouvilleiceras matsumotoi Obata, 1969
Fig. 9A–J

1969 *Eodouvilleiceras matsumotoi* Obata, pp. 166–169, p. 18, figs. 2, 3, 5; pl. 19, fig. 2; text-fig. 1.

2013 Douvilleiceratacеae gen. *et* sp. indet., Inose *et al*., figs. 5–6, 7.

2018 *Douvilleiceras matsumotoi*, Obata and Matsukawa, p. 259.

Material. Three specimens. (1) TGUSE-MM 6174 (T. Kase collector) is a partial outer whorl, and obliquely deformed, and comes from the upper part of the Hiraiga Formation at location Ks 2005, Hideshima fishing port in Miyako City. (2) NMNS-PM 23796 (Inose *et al*. collectors) and (3) NMNS-PM 23797 (Inose *et al*. collectors) are partial shells of very small specimens, and come from the Sakiyama Formation al location Loc. 2, Ebisudana, coast of Hideshima, Miyako City.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	H	W	W/H
TGUSE-MM 6174	---	---	---	7.9	19.0	2.41
NMNS-PM 23796	7.1+	2.3	0.32+	2.4	---	---
NMNS-PM 23797	5.8	2.9	0.50	2.1	4.3	2.04

Descriptive remarks. The specimens are characterized by a depressed whorl, coronate whorl-section, whorl surface ornamented with prorsiradiate ribs which arise at the umbilical shoulder, proceed straight on flank and cross the venter orthogonally. The ribs consist of alternating thick majors and thin and weak minors. Major ribs bear small umbilical bullae, lateral tubercles, and mammillate ventral tubercles. Bifurcated ventral tubercles cannot be confirmed because these tops of large specimen (TGUSE-MM 6174) have been broken. In addition, small specimens (NMNS-PM 23796 and 23797) have undeveloped tubercle bulge. The characteristics are not conspicuous in juvenile shells of the *E. matsumotoi* (Obata, 1969, pl. 18, figs. 2, 3). The specimens are identified as *Eodouvilleiceras matsumotoi* (Obata, 1969, pp. 166–169, p. 18, figs. 2, 3, 5; pl. 19, fig. 2; text–fig. 1) from the lower part of the Hiraiga Formation.

Occurrence. The genus is reported from France (Jacob, 1905), the Caucasus (Egoian, 1969), Georgia (Eristavi, 1955), Turkmenistan (Urmanova, 1962), the lower Albian of Texas (Scott, 1940), the upper Aptian Colombia (Riedel, 1938), Kumamoto, Japan (Matsumoto and Tamura, 1968) and the uppermost Aptian of Miyako, Japan (Obata, 1969).

Family Trochleiceratidae Breistroffer, 1951
Genus *Pseudoleymeriella* Casey, 1957

Pseudoleymeriella hataii Obata, 1973
Figs. 9K–M

1973 *Pseudoleymeriella hataii* Obata, pp. 309–312, pl. 34, figs. 1, 2, 4, 5, 7, 8; text–figs. 1, 2.

2013 *Pseudoleymeriella hataii*, Inose *et al*., figs. 5–2a, b.

Material. NMNS-PM 23791 (Inose *et al*. collectors), shell, from the Sakiyama Formation at location Loc. 2, Ebisudana, Hideshima coast, Miyako City.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	H	W	W/H
NMNS-PM 23791	18.3	5.9	0.32	8.7	6.8	0.78

Descriptive remarks. Based on the presence of ribs interrupted on the venter, and ventrolateral tubercles but no lateral tubercles on the ribs, the specimen is identified as *Pseudoleymeriella hataii* (Obata, 1973, pp. 309–312, pl. 34, figs. 1, 2, 4, 5, 7, 8; text–figs. 1, 2) from the upper part of the Hiraiga and Aketo formations of the Tanohata area.

Occurrence. The genus is reported from British Columbia, Canada (Whiteaves, 1893), the Aptian of Madagascar (Collignon, 1962) and Spain (Wiedmann, 1966), and Japan (Obata, 1973).

Superfamily Deshayesitaceae Stoyanow, 1949
Family Parahoplitidae Spath, 1922
Subfamily Acanthohoplitinae Stoyanow, 1949
Genus *Hypacanthoplites* Spath, 1923

Hypacanthoplites subcornuerianus (Shimizu, 1931)
Figs. 10S–X

1931 *Acanthoplites subcornuerianus* Shimizu, pp. 32–33, pl. 1, figs. 8, 9

1968 *Hypacanthoplites subcornuerianus* (Shimizu), Hanai *et al*., pl. 2, Fig. 6

1980 *Hypacanthoplites subcornuerianus* (Shimizu), Obata and Matsukawa, pp. 185-213, 189, pls. 23, 24.

Material. Thirteen specimens. (1) IGPS 36512 (S. Shimizu collector), type specimen of the species, shell is flattened, comes from location OH 4, Hideshima fishing port, Miyako City. (2) TGUSE-MM 6415, (3) 6417, (4) 6418, (5) 6422, (6) 6423, (7) 6427, (8) 6453, (9) 6454 (I. Obata collector), all from location OH 4. (10) 6420 (H. Yaegashi collector), from location Ob1, and (11) 6450, (12) 6451, (13) 6452 (T. Kase collector), from the Hiraiga Formation at location Ks2005.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	H	W	W/H
TGUSE-MM 6415	ca. 25.3	8.0	ca. 0.31	10.3	---	---
TGUSE-MM 6420	---	---	--	8.6	---	---
TGUSE-MM 6451	14.1	4.2	0.30	6.0	6.1	1.01

Descriptive remarks. Because of its rectangular whorl-section, broadly arched venter, straight and broad primary ribs with umbilical bullae, ventrolateral tubercles, and faint projection on the venter, as well as narrow secondary ribs, the specimens are identified as *Hypacanthoplites subcornuerianus* (Shimizu, 1931).

Occurrence. All specimens came from the Hiraiga Formation.

Hypacanthoplites cf. *anglicus* Casey, 1965
Fig. 10A–K

Compare.

1965 *Hypacanthoplites anglicus* Casey, pp. 427–428, pl. 71, figs. 4–7; pl. 74, fig. 2; text-figs. 162a, d, g.

Material. Three specimens, TGUSE-MM 6424, 6425, and 6246 (all I. Obata collector), are all partial whorls and internal molds, and come from the upper part of the Hiraiga Formation at location OH 4, Hideshima fishing port, Miyako City, Iwate Prefecture. They have been slightly deformed obliquely by pressure.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	H	W	W/H
TGUSE-MM 6424	---	---	---	9.1	4.7	0.52
TGUSE-MM 6425	---	---	---	8.4	5.2	0.62
TGUSE-MM 6426	---	---	---	12.3	7.4	0.60

Descriptive remarks. The specimens exhibit a highly rectangular whorl-section, with flat flanks and flat venter, deep umbilicus with steep wall and rounded margin. The flank surface is ornamented with coarse ribs consisting of primaries and secondaries. The primary ribs arise at umbilical bullae, trend straight across the flank and cross the venter orthogonally. The secondary ribs arise at mid-flank and some of them arise at lower flanks, and cross the venter orthogonally. The primary ribs and the secondary ribs alternate, or the secondary ribs are inserted every two to four primary ribs. The width of ribs on the venter is the same for both primaries and secondaries. The width of the interspace between the ribs is about twice that of width of the ribs themselves. The number of ribs is 10 to 12. Ribs have bullae and also two rows of tubercles; the first row is located at the outer flank, the second one at the ventral shoulder.

The ribbing pattern of the present specimens, in which the primary and secondary ribs alternate and the secondary ribs are inserted every two to four primary ribs, is similar to the illustrated specimens of *Hypacanthoplites anglicus* (Casey, 1965, pl. 71, figs. 4–7) from the upper Aptian of the Lower Greensand, southern England. However, the ribs of the present specimens are thicker than those of the English specimens. We, therefore, identify the specimen as *Hypacanthoplites* cf. *anglicus*.

Occurrence. *Hypacanthoplites anglicus* is reported from the Aptian of England (Casey, 1965), the Aptian of France (Breistroffer, 1947; Marechal, 1994; Kennedy *et al*., 2000), the Albian of Georgia (Eristavi, 1961) and Germany (Kemper, 1975), the Aptian of Ethiopia (Zeiss,

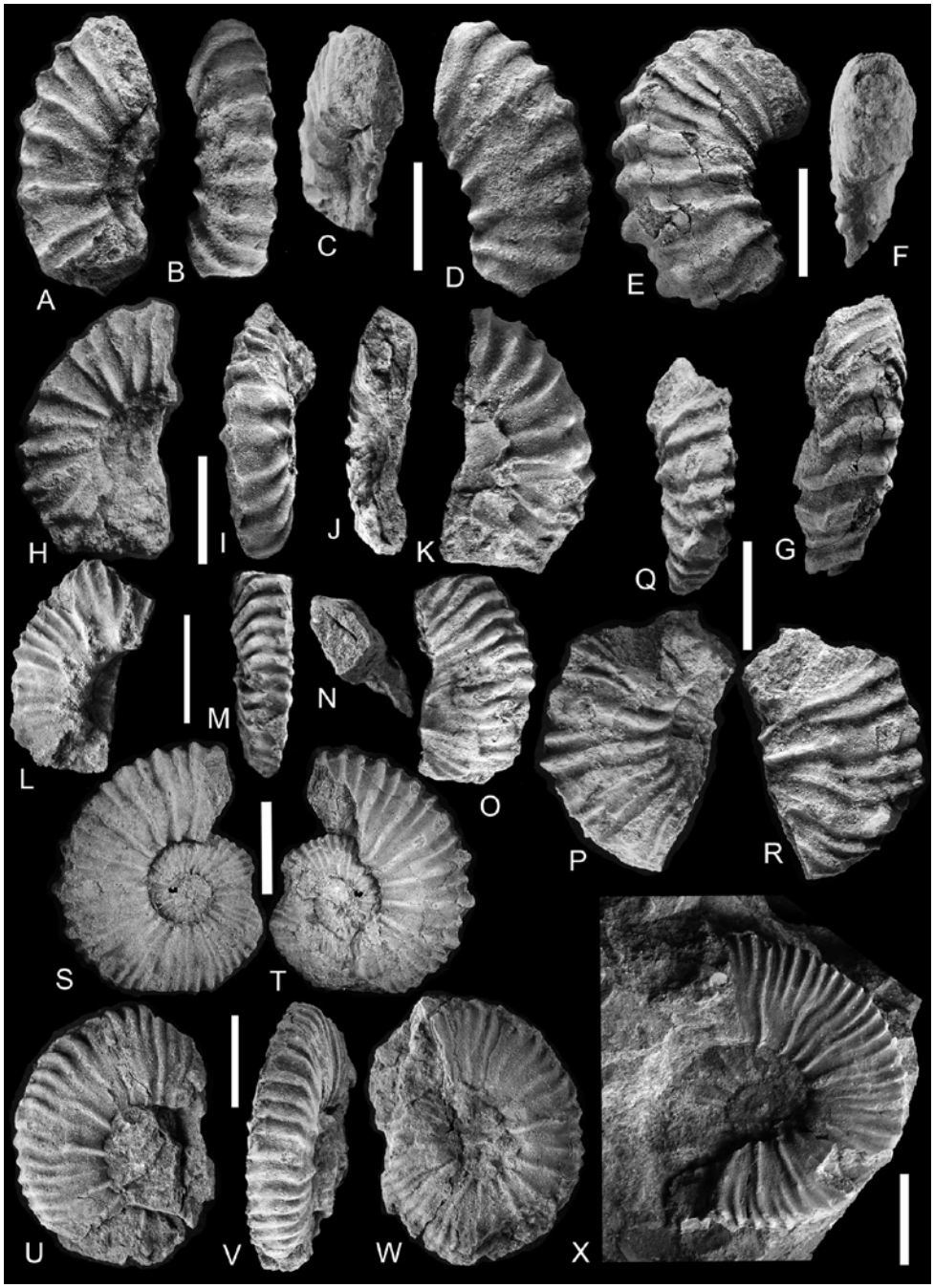

Fig. 10 A-K, *Hypacanthoplites* cf. *anglicus*; A-D, TGUSE-MM 6424 (I. Obata collector), shell, Hiraiga Formation (loc. OH4),lateral (A and D), ventral (B), and frontal (C) views. E-G, TGUSE-MM 6426 (I. Obata collector), shell, Hiraiga Formation (loc. OH4), lateral (E), frontal (F), and ventral (G) views. H-K, TGISE-MM 6425 (I. Obata collector), shell, Hiraiga Formation (loc. OH4), lateral (H and K), ventral (I) and frontal (J) views. L-O, *Hypacanthoplites* cf. *elegans*; TGUSE-MM 6429 (I. Obata collector), shell, Hiraiga Formation (loc. OH4), lateral (L and O), ventral (M) and frontal (N) views. P-R, *Hypacanthoplites* sp.; TGUSE-MM 6430 (I. Obata collector), shell, Hiraiga Formation (loc. OH4), lateral (P and R), and ventral (Q) views. S-X, *Hypacanthoplites subcornuerianus*; S and T, IGPS 36512 (S. Shimizu collector), holotype, shell, Hiraiga Formation (loc. OH4), ventral views (S and T). U-W, TGUSE-MM 6422 (I. Obata collector), shell, Hiraiga Formation (loc. OH4), lateral (U and W) and ventral (V) views. X, TGUSE-MM 6450 (T. Kase collector), shell, Hiraiga Formation (loc. Ks2005, lateral view. Scale bars show 1 cm.

1975), the Aptian-Albian Austria (Follmi, 1989), the Caucasus (Baraboshkin, 1999), and Iran (Raisossadat, 2006).

Hypacanthoplites cf. *elegans* (Fritel, 1906)
Figs. 10L–O

Compare.

1965 *Hypacanthoplites elegans*, Casey, p. 439–440, pl. 71, figs. 1a, b; pl. 72, fig. 3; pl. 74, figs. 10a, b; text–fig. 163a–c.

2000 *Hypacanthoplites elegans*, Kennedy, p. 694-696, figs. 38a-m, 53j, k, 57a-I, k-q.

Material. A single specimen, TGUSE-MM 6429 (I. Obata collector), a partial internal mold of whorl, from the Hiraiga Formation at location OH4, Hideshima fishing port, Miyako City, Iwate Prefecture. The specimen is obliquely deformed by pressure and the top of a bullae is broken.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	H	W	W/H
TGUSE-MM 6429	---	---	---	8.0	3.6	0.45

Descriptive remarks. The specimen is characterized by a compressed, sub-rectangular whorl-section with flat flanks and flat venter, flank surface ornamented with dense, slightly prorsiradiate straight ribs which cross the venter orthogonally. The ventral shoulder is sub-angulate. There are four bullae on the umbilical shoulder; these give rise to three ribs with intercalated ribs inserted low on the flank. The ribs are prorsiradiate, feebly convex on the inner flank, extending forward and feebly convex on the outer flank. Very small tubercles forming projections are found on ribs at the outer flank and small ventrolateral tubercles are presence on all ribs. Based on these features, the present specimen belongs to the genus *Hypacanthoplites* (Wright *et al*., 1996). The presence of three ribs which arise at the umbilical bullae, with associated intercalated ribs, is similarly seen on the illustrated specimens of *Hypacanthoplites elegans* of Kennedy *et al*. (2000, figs. 38a–m, 53j, k, 57a–I, k–q), from the upper Aptian of Germany. The German specimens differ from the Japanese one in that the umbilical bullae of those specimens exhibit a pair of ribs and rarely three, whereas Japanese specimen shows three ribs. Additionally, the illustrated specimens of *H. elegans* (BM. C11763, text–fig. 163a–c in Casey, 1965) from Germany have more prominent umbilical bullae than the present specimen. Since the present specimen is only a partial fragment of deformed outer shell, we identify it as *Hypacanthoplites* cf. *elegans*.

Occurrence. *Hypacanthoplites elegans* is reported from upper Aptian of southern and northern France, southern England, Germany, and Central Asia (Kennedy *et al*., 2000).

Hypacanthoplites sp.
Fig. 10P–R

Material. A single specimen, TGUSE-MM 6430 (I. Obata collector), is a part of outer whorl, and comes from the upper part of the Hiraiga Formation at location OH4, Hideshima fishing port, Miyako City. The specimen is deformed obliquely.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	H	W	W/H
TGUSE-MM 6430	---	---	---	10.8	6.5	0.60

Descriptive remarks. The specimen is characterized by rectangular whorl-section with round flanks and flat venter, shallow umbilicus with steep wall and rounded margin, whorl surface ornamented with dense, sinuous ribs that consist of the primaries and the secondaries. The primary ribs arise at the umbilical bullae, pass along the flanks, and cross the venter orthogonally. The secondary ribs arise at umbilical the margin and/or the middle of the flank. Primary and secondary ribs alternate, or the secondary ribs are inserted every one to four primary ribs. The width of the interspace between ribs is the same as that of rib width. The number of ribs is seven. Ribs have bullae and also two rows of tubercles; the first row is located at mi-flanks and the second one at the ventral shoulder. Based on these features, the specimen belongs to the genus *Hypacanthoplites* (Wright *et al*., 1996). The specimen differs from the specimens of *Hypacanthoplites subcornuerianus* in that its secondary ribs arise weakly at the lower and/or mid-flank. Therefore, we identify the specimen as *Hypacanthoplites* sp.

Subfamily Parahoplitinae Spath, 1922
Genus *Parahoplites* Anthula, 1899
Parahoplites cf. *laticostatus* (Sinzow, 1907)

Fig. 11

Compare.

1907 *Acanthohoplites laticostatus* Sinzow, pp. 482–483, pl. 5, figs. 9–13.

1938 *Parahoplitoides cerrosensis*, Anderson, pp. 168–169, pl. 33, fig. 1.

1953 *Acanthohoplites laticostatus*, Glazunova, pp. 41, pl. 7, figs. 2a-c, text–fig. 16.

1962 *Acanthohoplites* cf. *laticostatus*, Collignon, p.56, pl. 237, fig. 1021.

2009 *Parahoplites laticostatus*, Lehmann *et al*., pp. 907–908, figs. 8E, F.

Material. A single specimen, IPMM30427 (S. Inomata collector), came from the Hiraiga Formation at location Ks 2005, sea floor of Hideshima fishing port, Miyako City. An inner shell of the specimen is not preserved.

Dimension (in mm except for U/D and W/H).

Specimen	D	U	U/D	H	W	W/H
IPMM 30427	225.0	69.5	0.31	79.6	---	---
-1/2 volution	---	---	---	64.3	73.1	1.14

Description. Shell is fairly large, discoidal, with maximum width near the umbilical shoulder. Width of the umbilicus proportional to the entire shell diameter is moderate and the whorl is very evolute; the overlapped part of the next inner whorl measured in the last whorl-height, shows a value of 0.17. Umbilical wall is steep and rounds to the flanks. Whorl is fairly depressed, trapezoid in cross-section, with inflated sides from a somewhat narrow convex venter to a broadened umbilical shoulder. Surface of the shell is ornamented with low, dense, slightly sinuous flat-topped ribs that are broad, right-triangle in cross-section, gentle sloped on the adapical side. The ribs arise at the umbilical seam, and some branch into two at the umbilical shoulder or the lower and middle flanks and arise at the middle flank in the earlier whorl; they are single on later whorls. The ribs cross the venter orthogonally. Suture line is unknown.

Remarks. Because the ribs lack tubercles, the specimen belongs to the genus *Parahoplites* (Wright *et al*., 1996).

Comparison. The present specimen of the species is similar to the specimen of *Parahoplitoides cerrosensis* (Anderson, 1938, p. 168-169, pl. 33, fig. 1) from the Shoup Creek section, a little above the Argonaut zone of the Horsetown Group, at locality CAS 1347, 6 miles south of Ono, Shasta County, California, in having sinuous ribs which are flat-topped on the outer whorl. The specimen is also similar to the illustrated specimens of *Acanthohoplites laticostatus* (Sinzow, 1907, pp. 482–483, pl. 5, fig. 9–13) from the Aptian of Mangyschlak in Kazakhstan and Caucasus, in that the trapezoidal whorl-section and surface is covered by dense, broad, and flat-topped ribs. But the ribs of Mangyschlak's specimens are more round than those of the present specimen. Therefore, it is better to identify the present specimens as comparative species of *Acanthohoplites laticostatus*. Subsequently, Lehmann *et al*. (2009, pp. 907–908, figs. 8E, F.) moved *Acanthohoplites laticostatus* in the genus *Parahoplites*. Therefor, the present specimen is identified as *Parahoplites* cf. *laticostatus* (Sinzow, 1907). The ribs of the present specimen cross the venter orthogonally. Ribs of the genus *Parahoplites* cross the venter forwardly convex, so the present specimen may belong to a different genus than *Parahoplites*. Since the only one specimen has been obtained so far, we hesitate to propose a new genus. The present specimen is different from the huge specimen of *Parahoplites colossus* (Matsumoto, 1984, pp. 21–24, pl. 1, figs. 1–3; pl. 2, figs. 1–3; text-fig. 1), from fallen block from a cliff the Kamiji Formation of the Lower Yezo Group along Pankenai river, because the expansion rate of the Lower Yezo Group specimen is greater than that of the present specimen, and the ribs of the present specimens are denser than those of the Lower Yezo Group specimen. Additionally, the ribs on the present specimen are broader than those of the Lower Yezo Group specimen.

Occurrence. The present species and the related species are reported from Kazakhstan and Caucasus (Sinzow, 1907; Glasunova, 1953), Japan (this paper), California (Anderson, 1938), Tunisia (Lehmann et al., 2009), and Madagascar (Collignon, 1962).

DISCUSSION

1) Lithostratigraphic Correlation

Lithostratigraphic correlation of the Miyako Group across the five regions of its distribution was first presented by Yabe and Yehara (1913), but their correlation was based mostly on biostratigraphy. In contrast, Hanai *et al*. (1968) considered that the

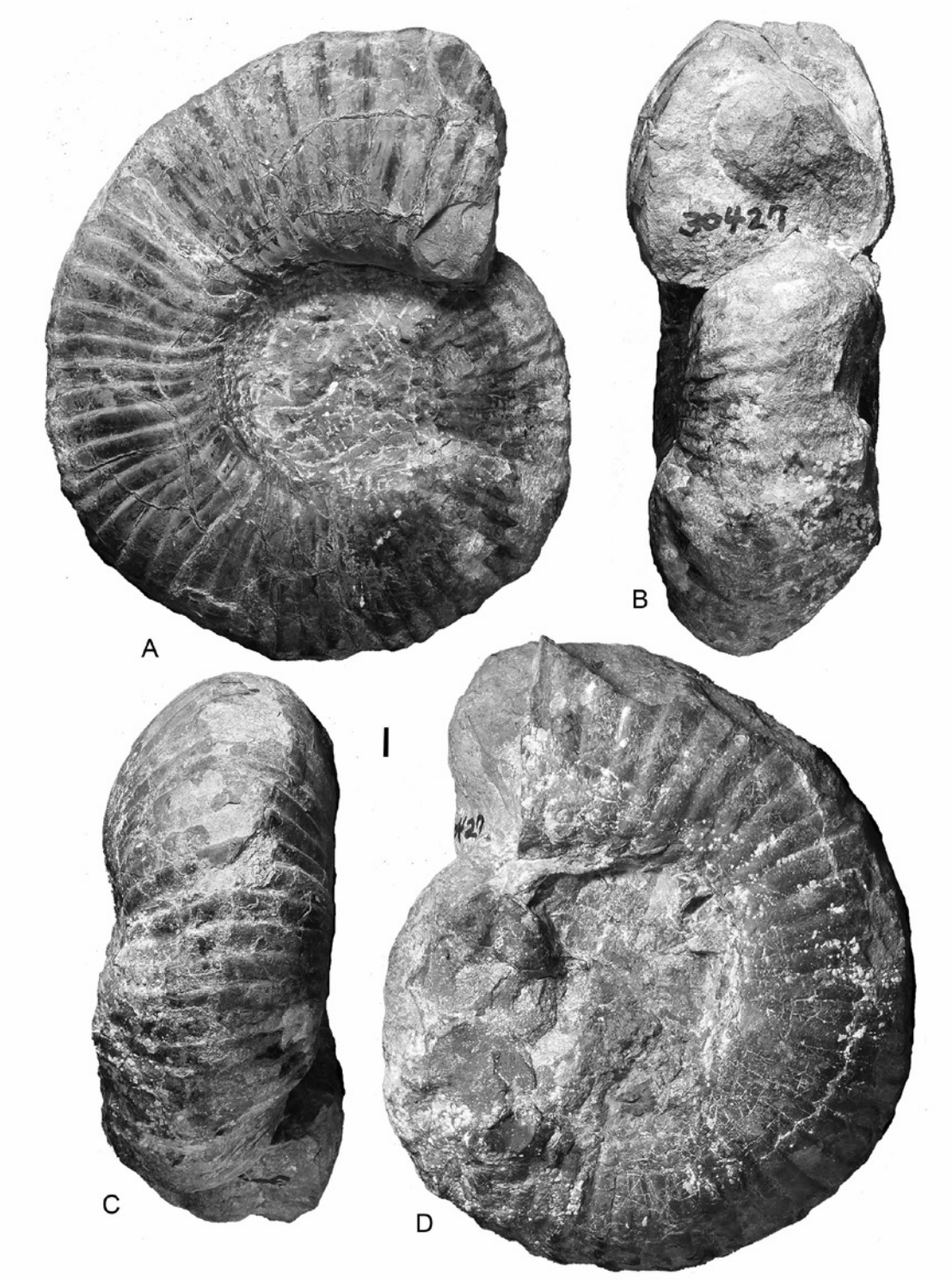

Fig. 11 *Parahoplites* cf. *laticostatus* (Sinzow, 1907), IPMM30427 (S. Inomata collector), shell, Hiraiga Formation (loc. Ks 2005), lateral (A and D), frontal (B), ventral (C) views. Scale bar shows 1 cm.

lithostratigraphy within the Miyako Group could be correlated on the basis of comparative successions of sedimentary cycles in the five regions. This correlation framework was followed largely by Shimazu *et al*. (1970).

In the Tanohata region, the type area of the Miyako Group, pebble- to boulder-sized conglomerates and breccias of the Raga Formation overlie the basement rocks (Hanai *et al*., 1968). Although the pebble- to boulder-sized conglomerates also cover the basement rocks in the Sakiyama region, the conglomerates are intercalated with fine-grained sandstones with hummocky cross-stratification (see Fig. 3). Pebbly fine-grained sandstones developing hummocky cross-stratification are also characteristic of the Tanohata Formation in the Tanohata region (Fujino *et al*., 2006; Fujino and Maeda, 2013). Alternating beds of conglomerates and hummocky cross-stratified sandstones in the Sakiyama region can thus be correlated to the pebbly sandstone with hummocky cross-stratification of the Tanohata Formation, rather than the basal clast-supported conglomerates and breccias of the Raga Formation in the Tanohata region (Fig. 12).

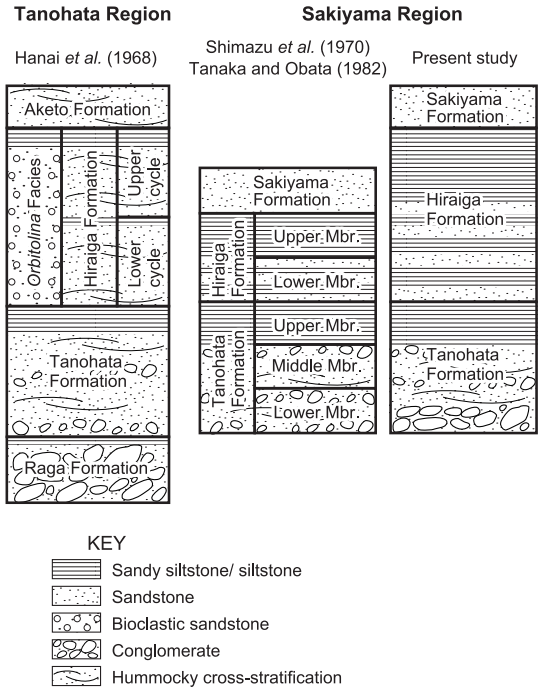

Fig. 12 Lithostratigraphic correlation between the Tanohata (Hanai *et al*., 1968) and Sakiyama (Shimazu *et al*., 1970; Tanaka and Obata, 1982; and the present study) regions. Schematic lithological features are also shown.

In the Tanohata region, the Hiraiga Formation, which rests on the Tanohata Formation, is composed of medium- to fine-grained calcareous sandstones and laterally equivalent bioclastic sandstones that include numerous *Orbitolina* sp. Based on thin sandy mudstone layers intercalated in the medium- to fine-grained calcareous sandstones in the middle part of the Hiraiga Formation, the formation is divided into two parts as the lower and upper cycles (Hanai *et al*., 1968). Shimazu *et al*. (1970) used the lithostratigraphy and correlation based on grain size changes by Hanai *et al*. (1968). They correlated the Hiraiga and Sakiyama formations in the Sakiyama region with the two cycles in the Hiraiga Formation in the Tanohata region (Fig. 12). However, the thin sandy mudstone layers in the *Orbitolina* facies in the Tanohata region are indistinct in the Tanohata region (Hanai *et al*., 1968; Shibata's observation in 2016 and 2022). This suggests that the two cycles of the Hiraiga Formation in the Tanohata region may not be correlated with the successions in other regions.

In the Sakiyama region, the Hiraiga Formation consists of alternating beds of fine-grained calcareous sandstones and sandy siltstones, with overlying dark gray, well-sorted siltstones, which represent an overall fining-upward trend. The medium- to fine-grained calcareous sandstones and laterally equivalent bioclastic sandstones in the Tanohata region are also characterized by overall upward-fining trends. We, therefore, correlate the sequence of the alternating beds of sandstones and sandy siltstones to the well-sorted siltstones in the Sakiyama region with the medium- to fine-grained calcareous sandstones and laterally equivalent bioclastic sandstones in the Tanohata region as the Hiraiga Formation. As a result, the overlying silty sandstones of the Sakiyama Formation in the Sakiyama region can be interpreted as correlative with the silty sandstones of the Aketo Formation in the Tanohata region (Fig. 12).

2) Ammonite Biostratigraphy of the Miyako Group in the Sakiyama Region

Fourty-five specimens from the Miyako Group were used for the study, which include the following specimens

described by Obata and Matsukawa (2018): four specimens of *Valdedorsella kasei* from Ks2005, Hy 2099 and Kc-e; and one specimen of *Nolaniceras*? *yaegashii* from the Hiraiga Formation (loc. Ebisudana) (Fig. 13). Based on Shimizu (1931, p. 7), the specimen described as *Parahoplites yaegashii* nov. sp. (Shimizu, 1931, p. 30-31, pl. 2, figs. 1, 2, 3) came from loc. Hideshima where the layer bearing the specimen is overlain by scores of meters the layer unit containing the specimen described as *Acanthoplites subcornuerianus* nov. sp. (Shimizu, 1931, p. 32-33, pl. 1, figs. 8, 9). The beds that yield the specimens of *A. subcornuerianus* and *P. yaegashii* correspond to those located at loc. OH 4 and loc. OH 5, respectively. The locality of the type specimen of *H. subcornuerianus* (IGPS 36512) was given as location Hn 2058 by Obata and Matsukawa (2018), but it is here corrected to location OH 4. Since the specimen listed as Desmoceratidae gen. *et* sp. indet. (table 1 in Inose *et al*., 2013), from location Loc. 3 of the Sakiyama Formation in Ebisudana, is not confirmed, that specimen is excluded from this study.

The stratigraphic distribution of the ammonite assemblages of the Miyako Group of the Sakiyama region can be divided into: (1) a combination of multiple teil zones forming biozones; and (2) single occurrences of characteristics species as specific biostratigraphic horizons. Since *Hypacanthoplites subcornuerianus* occurs in lithologic horizons OH4, Ob01, and Ks2005, all included in the Hiraiga Formation, these strata can be recognized as comprising a biozone. The lithostratigraphic horizon Ks2005 also yields *Diadochoceras nodosocostatiforme* as a biostratigraphic horizon. According to Obata and Matsukawa (2018), *H. subcornuerianus* and *D. nodosocostatiforme* are utilized as zonal species of the *H. subcornuerianus* and overlying *D. nodosocostatiforme* zones, respectively. Based on the occurrences of these two species, the Hiraiga Formation can be divided as a lithostratigraphic unit into the *H. subcornuerianus* Zone that is a sequence from lithostratigraphic horizons OH4 and Ob1, and as the "*D. nodosocostatiforme* biostratigraphic horizon." The lithostratigraphic horizon OH5 that is included in the Sakiyama Formation yields *Valdedorsella kasei* as a characteristic species, which is also found in the lithostratigraphic horizon Ks2005. These occurrences are thus regarded as the "*Valdedorsella kasei* Zone." However, since *Diadochoceras nodosocostatiforme* is employed as the zonal species of the *Diadochoceras nodosocostatiforme* Zone of the Miyako Group, it is more appropriate to identify the lithostratigraphic horizon Ks2005 as a part of the *D. nodosocostatiforme* Zone than an utilizing the *Valdedorsella kasei* Zone. Furthermore, since the lithostratigraphic horizon OH5 does not yield common species in its higher lithostratigraphic horizons (Locs. 1 and 2), it is more appropriate to identify the lithostratigraphic horizon OH 5 as the upper part of the *D. nodosocostatiforme* Zone. *Eodouvilleiceras matsumotoi* is also found in the lithostratigraphic horizon Ks2005 of the uppermost of the Hiraiga Formation and at Loc. 2 of the Sakiyama Formation, respectively. This species is a member of the assemblage of the *Diadochoceras nodosocostatiforme* Zone, which is the middle of the three zones which characterize the Miyako Group, the *H. subcornuerianus*, *Diadochoceras nodosocostatiforme*, and *Douvilleiceras mammillatum* zones (Obata and Matsukawa, 2018). The lithostratigraphic horizon Ks2005 can thus be regarded as the *Diadochoceras nodosocostatiforme* Zone. Finally, *Marshallites miyakoensis* occurs in lithostratigraphic horizons OH4, Ob01 and Loc. 1 that are included in the Hiraiga and Sakiyama formations. These three locations with *M. miyakoensis* are shown as a teil zone, but the lower of two localities are included in the *H. subcornuerianus* Zone. Both of the lithostratigraphic horizons OH4 and Ob01 yield both *Hypacanthoplites subcornuerianus* and *Marshallites miyakoensis*. *Marshallites miyakoensis* occurs only in the Aketo Formation in the Tanohata region that is assigned to the *Douvilleiceras mammillatum* Zone. These lithostratigraphic horizons are interpreted as the overlap of the *H. subcornuerianus* and *Douvilleiceras mammillatum* zones, as defined by Obata and Matsukawa (2018). Loc. 1 yields *Marshallites miyakoensis* without *H. subcornuerianus* similar to the *Marshallites miyakoensis* location in the Aketo Formation. Loc. 1 is interpreted to be in the *Douvilleiceras mammillatum* Zone. Since the two lithostratigraphic horizons, OH4 and Ob01, both yield *Hypacanthoplites subcornuerianus* and *Marshallites miyakoensis*, it is more appropriate to identify both lithostratigraphic horizons as the *H. subcornuerianus* Zone, rather than as the *D. mammillatum* Zone.

Based on Obata and Matsukawa (2018), both the *H. subcornuerianus* and *D. nodosocostatiforme* zones are assigned to the Aptian, and the *D. mammillatum* Zone is assigned to the lower Albian. Accordingly, the Hiraiga Formation is Aptian, and the Sakiyama Formation is upper Aptian to lower Albian. The boundary between the Aptian and Albian stages is to be found somewhere between locations the OH5 and Loc. 1 in the Sakiyama Formation. This supports the conclusion of Inose *et al*. (2013) that the Sakiyama Formation is correlated with the upper Aptian to lower Albian.

3) Confirmation of Stratigraphic Relationship of Three Ammonite Biozones in the Miyako Group

According to Obata and Matsukawa (2018), three ammonite biozones are recognized in the Miyako Group:

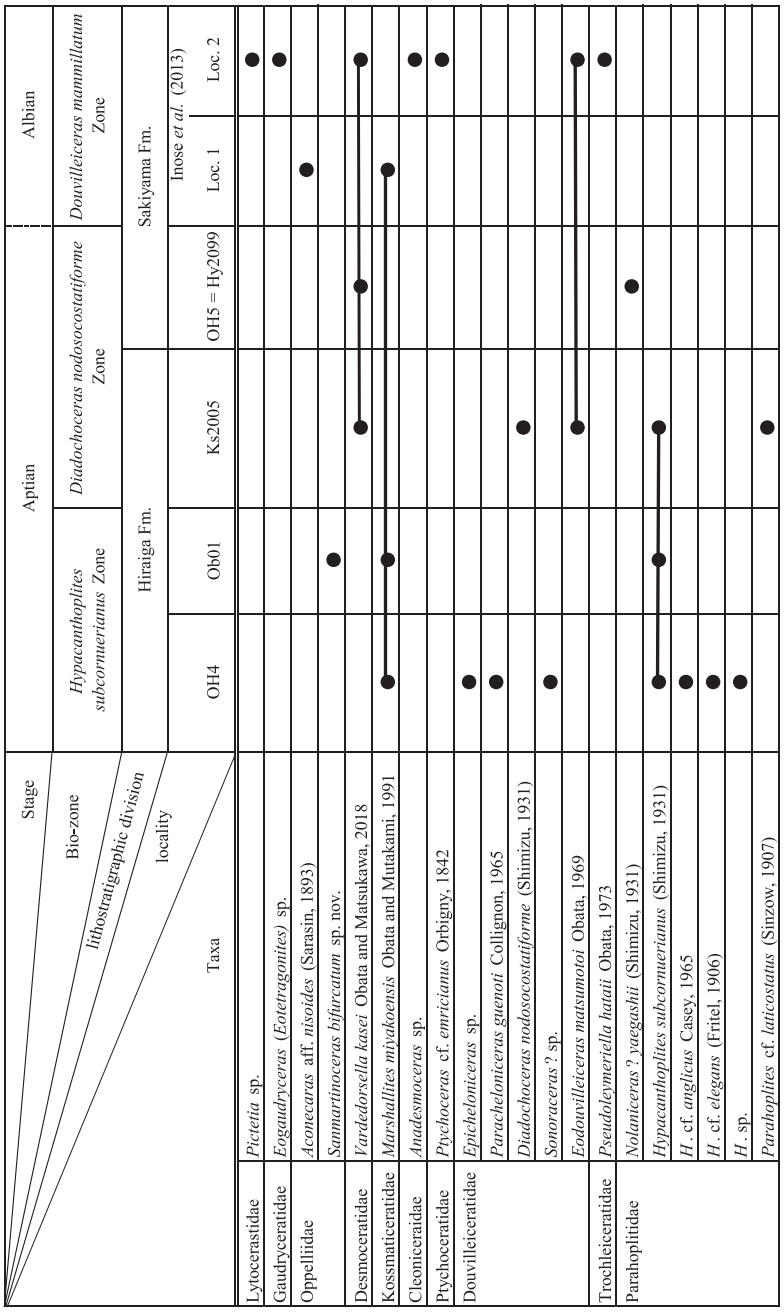

Fig. 13 Biostratigraphic distribution of ammonites of the Miyako Group in the Sakiyama region. Solid circles show ammonites. Black band shows range of ammonite species.

(1) the *Hypacanthoplites subcornuerianus* Zone, comprising the Tanohata Formation and the lower portion of the upper part of the Hiraiga Formation; (2) the *Diadochoceras nodosocostatiforme* Zone, in the upper part of the Hiraiga Formation, and (3) the *Douvilleiceras mammillatum* Zone in the uppermost part of the Hiraiga Formation and the Aketo Formation. Before establishing a basin-wide biostratigraphic correlations for the Miyako Group, the succession of biostratigraphic zones should be confirmed by lithostratigraphic correlation among the five discontinuously distributed outcrop regions of the Miyako Group. If it is not always possible to trace the lithologically subdivided strata laterally, it is the necessary to demonstrate that correlation of the lithostratigraphic units by ammonite biostratigraphy is valid and effective. The *Diadochoceras nodosocostatiforme* Zone was established based on the assemblage in the upper part of the Hiraiga Formation in the Moshi region, where the zone is found between the underlying *Hypacanthoplites subcornuerianus* Zone and the overlaying *Douvilleiceras mammillatum* Zone. In the Sakiyama region, however, it has not been confirmed that the *D. nodosocostatiforme* Zone falls between the stratigraphy lower *Hypacanthoplites subcornuerianus* Zone and stratigraphically younger *Douvilleiceras mammillatum* Zone.

In the Sakiyama region, *Eodouvilleiceras matsumotoi*, which is found in the upper part of the Hiraiga Formation at Loc. Ks 2005, is a member of the assemblage that constitutes the *Diadochoceras nodosocostatiforme* Zone. From the Sakiyama Formation at Loc. 2, *E. matsumotoi* is also a member of the assemblage that constitute the *Douvilleiceras mammillatum* Zone. *Hypacanthoplites subcornuerianus* is also found at the lithostratigraphic horizon of the Loc. Ks 2005, as well as the underlying two lithostratigraphic horizons; the level of the Loc. Ks 2005, excluding the two underlying horizons, is identified as the *Hypacanthoplites subcornuerianus* Zone. In the Sakiyama region, the biostratigraphic relationship between the *Hypacanthoplites subcornuerianus* Zone and the *Diadochoceras nodosocostatiforme* Zone can therefore be confirmed.

Marshallites miyakoensis is a member of the assemblage that makes up of the *Douvilleiceras mammillatum* Zone in the Aketo Formation. In the Sakiyama region, this species is also found in the Hiraiga Formation and it is also a member of the *Hypacanthoplites subcornuerianus* Zone and *Diadochoceras nodosocostatiforme* Zone assemblages. However, the upper part of the Sakiyama Formation can be identified as the *Douvilleiceras mammillatum* Zone because it contains *Marshallites miyakoensis*. This confirms that hierarchical relationship between the *Diadochoceras nodosocostatiforme* Zone and the *Douvilleiceras mammillatum* Zone, which indicates that the stratigraphic relationship of the three ammonite biozones of the Miyako Group can be confirmed in the Sakiyama region.

4) Correlation with Other Regions

According to Reboulet *et al*. (2018), ammonite standard zonation of the upper Aptian to lower Albian stages for the West Mediterranean Province of the Tethyan Realm is divided into four zones in ascending stratigraphic order. These are the *Epicheloniceras martini, Parahoplites melchioris*, *Acanthohoplites nolani* and *Hypacanthoplites jacobi* zones in the upper Aptian, and the *Leymeriella tardefurcata* and *Douvilleiceras mammillatum* zones in the lower Albian. The sequence from the *Hypacanthoplites subcornuerianus* to *Diadochoceras nodosocostatiforme* zones of the Miyako Group can be considered correlative with the sequence from the *Acanthohoplites nolani* Zone including the *Diadochoceras nodosocostatum* Subzone in its lower part and the *Hypacanthoplites jacobi* Zone of the ammonite standard zonation for the upper Aptian for the West Mediterranean Province. The two biozones of the Miyako Group and the ammonite standard zonation are complimentary.

In the Miyako Group, the *Douvilleiceras mammillatum* Zone overlies the *Diadochoceras nodosocostatiforme* Zone, and there is a lack of a specific ammonite biozone corresponding to the *Leymeriella tardefurcata* Zone between the *H. jacobi* and *Douvilleiceras mammillatum* zones of the ammonite standard zonation. Both zones are assigned to the uppermost zone of the Aptian and the upper zone in two zones of the Albian stages, respectively. Thus, the Aptian/Albian boundary cannot be defined with any precision in the Miyako Group. This lack of the *Leymeriella tardefurcata* Zone is also noted in

California (Murphy, 1956) and Mexico (Samaniego-Pesqueira *et al*., 2021) along the circum-North Pacific rim. This may be related to two possibilities: (1) the biogeographic distribution of *Leymeriella tardefurcata* itself did not extend to the circum-North Pacific region; and / or (2) physical and biogeographic connections between both circum-North Pacific Realm and the Tethyan Realm with the West European region were closed during the transition from Aptian to Albian time.

5) Characteristics of Miyako Group Ammonite Assemblages in the Sakiyama Region

In the above analysis, we have divided the ammonite fauna of the Miyako Group into three distinct assemblages based on the biostratigraphic zonation. The characteristics of ammonite morphotypes found in the three ammonite assemblages of the lowest *Hypacanthoplites subcornuerianus* Zone, the middle *Diadochoceras nodosocostatiforme* Zone, and the highest *Douvilleiceras mammillatum* Zone are as follows.

The lower ammonite assemblage, from locations OH4 and Ob01, representing the *Hypacanthoplites subcornuerianus* Zone, consists of *Sanmartinoceras bifurcatum*, *Marshallites miyakoensis*, *Epicheloniceras* sp., *Parachelonicerasguenoti*, *Sonoraceras*? sp., *Hypacanthoplites subcornuerianus*, *H.* cf. *anglicus*, *H.* cf. *elegans* and *H.* sp. Morphotypes of the lower assemblage include: (1) dominantly ornate planispiral form representing five genera (one species of one genus of Kossmaticeratidae, three species of three genera of Douvilleiceratidae, four species of one genus of Parahoplitidae); and (2) smooth or smooth or weakly ornate planispiral forms consisting of one genus (one species of one genus of Oppeliidae) (Fig. 14).

The middle ammonite assemblage, from localities Ks2005 and OH5, representing the *Diadochoceras nodosocostatiforme* Zone, comprises the taxa *Valdedorsella kasei*, *Diadochoceras nodosocostatiforme*, *Eodouvilleiceras matsumotoi*, *Hypacanthoplites subcornuerianus* and *Parahoplites* cf. *laticostatus*. Morphotypes of this middle ammonite assemblage include: (1) dominantly ornate planispiral forms consisting of five genera (two species of two genera of Douvilleiceratidae, three species of three genera of Parahoplitidae), and (2) smooth or smooth or weakly ornate planispiral forms consisting of one species of one genus of Desmoceratidae).

The uppermost of the three assemblages, from localities Loc. 1 and Loc.2, represents the *Douvilleiceras mammillatum* Zone and includes *Pictetia* sp., *Eogaudryceras* (*Eotetragonites*) sp., *Aconeceras* aff. *nisoides*, *Valdedorsella kasei*, *Anadesmoceras* sp., *Marshallites miyakoensis*, *Ptychoceras* cf. *emericianum*, *Eodouvilleiceras matsumotoi*, and *Pseudoleymeriella*

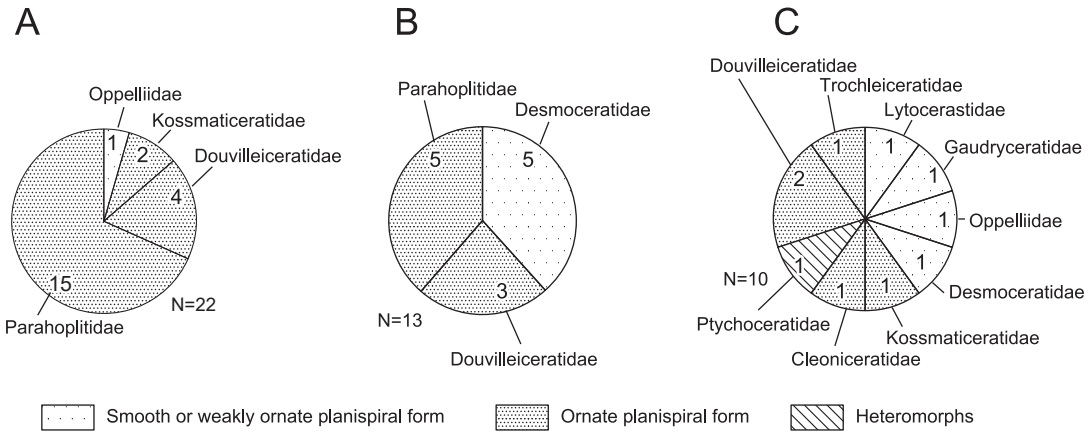

Fig. 14 Diagrams displaying the abundance of specimens in the ammonite assemblages of *Hypacanthoplites subcornuerianus* Zone (A), *Diadochoceras nodosocostatiforme* Zone (B) and *Douvilleiceras mammillatum* Zone (C) of the Miyako Group in Sakiyama region in Miyako City, Iwate Prefecture. Numbers indicate the number of specimens.

hataii. Morphotypes of the upper assemblage include: (1) dominantly smooth or weakly ornate planispiral forms consisting of five species of five genera (one species of one genus of Lytoceratidae, Gaudryceratidae, Oppeliidae, Desmoceratidae, and Cleoniceratidae); (2) ornate planispiral forms consisting of three genera (one species of one genus of Kossmaticeratidae, Trochleiceratidae, and Douvilleiceratidae); and (3) heteromorph forms consisting of one genus (one species of one genus of Ptychoceratidae).

The upper assemblage is the most diverse of the three taxonomically and morphologically, and may reflect the expansion of ammonite habitats during this marine transgression episode (Obata and Matsukawa, 2018).

CONCLUSIONS

1. The Miyako Group of the Sakiyama region is divided lithostratigraphically into the Tanohata, Hiraiga, and Sakiyama formations, in ascending order.
2. Ammonites from the Hiraiga and Sakiyama formations represent 20 species of 17 genera, including one new species, and are described systematically. Three ammonite assemblages can be recognized from the lower, middle, and upper parts of the Miyako Group in the Sakiyama region. The lower and middle assemblages are included in the sequence from the top of the Hiraiga Formation and the lower part of the Sakiyama Formation, while the upper assemblage is included in the upper part of the Sakiyama Formation. The lower assemblage consists of nine species, including *Hypacanthoplites subcornuerianus*, the middle assemblage consists of seven species, including *Diadochoceras nodosocostatiforme*, and the upper assemblage consists of nine species, including *Marshallites miyakoensis*. These assemblages are identified as characteristic of the *Hypacanthoplites subcornuerianus*, *Diadochoceras nodosocostatiforme*, and *Douvilleiceras mammillatum* zones of the Miyako Group, respectively. They are assigned to the upper Aptian – lower Albian of ammonite standard zonation for the West Mediterranean province of the Tethyan realm.
3. The morphotypes represented in the ammonite assemblages are smooth or weakly ornate planispiral forms, ornate planispiral forms, and heteromorphs. The ranking of morphotypes of the ammonite assemblage of the Miyako Group in the Sakiyama region shows ornate and slightly smooth or weakly ornate planispiral forms predominate initially. These become predominating smooth or weakly ornate planispiral forms in the middle assemblage. Finally, the uppermost assemblage is dominated by smooth or weakly ornate planispiral forms and slightly ornate planispiral forms and heteromorphs. The change in the diversity of shell morphology of the ammonite assemblages from the Hiraiga to Sakiyama Formation of the Miyako Group reflects an environmental change from proximal to distal marine environments during the late Aptian to the early Albian marine transgression.

ACKNOWLEDGMENTS

We thank Dr. Niall J. Mateer (University of California, Berkeley, retired) for critical reading of an early version of the manuscript, Dr. J. W. Haggart (Geological Survey of Canada, Vancouver) for linguistic editing and helpful discussion, Dr. J. A. Moreno-Bedmar (Universidad Nacional Autónoma de México) also for their helpful comments and information of ammonite taxonomy, the late Dr. I. Obata (National Museum of Nature and Science) for discussion ammonite biostratigraphy of the Miyako Group, and Dr. T. Oji (University Museum, Nagoya University) for helpful information of stratigraphy of the Miyako Group. We are indebted to S. Hasegawa (Kaizuka Museum of the Miyako City) for providing the specimens for study. This work was supported in part by JSPS KAKENHI Grant Number JP21K01010.

REFERENCES

Aguirre-Urreta M. B., Rawson P. F., Concheyro G. A., Bown P. R. and Ottone E. G. 2005. Lower Cretaceous (Berriasian – Aptian) biostratigraphy of the Neuquén Basin. *In* Veiga D. D., Spaletti L. A., Howell J. A. and Schwarz E. eds. *The Neuquén Basin, Argentina: A case study in Sequence Stratigraphy and Basin Dynamics*. *Geological Society, London, Special Publications*,

(252): 57–71.

Alabushev A. 1995. Ammonite faunas and biostratigraphy of the Albian to middle Cenomanian (Cretaceous) in western Korjak-Kamchatka, NE Russia. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, **196** (1): 109–139.

Anderson F. M. 1938. *Lower Cretaceous deposits in California and Oregon*. x + 339 pp. Geological Society of America, Special Paper 16.

Anthula D.J. 1899. Über die Kreidefossilien des Kaukasus mit einem allegemeinen Ueberblick über die Entwicklung der Sedimentärbildungen des Kaukasus. *Beiträge zur Paläeontologie und Geologie Öesterreich-Ungarns und des Orients*, **12** (1899): 55–160, pl.2–14.

Arkell W. J., Furnish W. M., Kummel B., Miller A. K., Moore R. C., Schindewolf O. H., Sylvester-Bradley P. C. and Wright C. W. 1957. Mesozoic Ammonoidea. *In* Moore R.C. ed. *Treatise on Invertebrate Paleontology, Part L. Mollusca 4, Cephalopoda, Ammonoidea*: L80–L465. The Geological Society of America, Boulder, and the University of Kansas Press, Lawrence.

Avram E. 1970. Precizări asupra vîrstei depozitelor Eocretacice din Bazinul Superior al Văii Tîrlungului. Studii şi Cercetări de Geolologie Geofizică Geografie, Seria Geologie. *Bucuresti, serie geologie*, **15**:165–174.

Avram E. 1995. Lower Cretaceous (Valanginian-Early Aptian) ammonite succession in the Sviniţa region (SW Rumania). *Geologie Alpine Memoire Hors Serie*, **20** (1994): 113–167.

Avram E., Duşa A. and Lupu D. 1990. La faune d' ammonites des couches de dumeşti (Monts Apuseni du sud, Romanie). Dări de Seamă ale Şedinţelor 3. *Paleontologie*, 74 (1987): 87–109.

Baraboshkin E. J. 1999. Albian ammonite biostratigraphy of the Northern Caucasus. *Neues Jahrbuch für Geologie und Palaontologie*, *Abhandlungen*, **212** (1–3): 175–210.

Bogdanova T. N. and Hoedemaeker Ph. J. 2004. Barremian-Early Albian Deshayesitidae, Oppeliidae, Desmoceratidae and Silesitidae of Colombia. *Scripta Geologica*, **128**: 183–312.

Bonarelli G. and Nágera J. 1921. Observaciones geologicas en las inmediaciones del Lago San Martin (Territorio de Santa Cruz). *Ministerio de Agricultura Boletin*, (27), Série B (Geología): 1–41.

Breistroffer M. 1947. Sur les zones d' ammonites dans l' Albien de France et d'Angleterre. *Travaux du Laboratoire de Géologie de la Faculté des Sciences de l' Université de Grenoble,* **26** (1946–1947): 17–104.

Breistroffer M. 1951. Sur quelques ammonites de l'Albien inférieur de Madagascar. *Compte Rendu sommaire des Séances de la Société géologique de France*, **1951**: 266–268.

Casey R. 1954. New genera and subgenera of Lower Cretaceous ammonites. *Journal of the Washington Academy of Sciences*, **44**: 106–115.

Casey R. 1957. The Cretaceous ammonite genus *Leymeriella*, with a systematic account of its British occurrences. *Palaeontology*, **1**: 29–59.

Casey R. 1961. The stratigraphical palaeontology of the Lower Greensand. *Palaeontology*, **3**: 487–621.

Casey R. 1962. A monograph of the Ammonoidea of the Lower Greensand. Part 4. *The Palaeontographical Society*, 217–288.

Casey R. 1965. A monograph of the Ammonoidea of the Lower Greensand. Part 6. *The Palaeontographical Society*, 399–546.

Casey R. 1966. A monograph of the Ammonoidea of the Lower Greensand, Part 7. *The Palaeontological Society*: 547–582.

Collignon M. 1956. Ammonites néocretacées du Menabe (Madagascar). IV. Les Phylloceratidae, V. Les Gaudryceratidae. VI. Tetragonitida. *Annales Géologiques du Service des Mines*, *Madagascar*, *Fascicule*, **23**: 7–107.

Collignon M. 1962. *Atlas des fossiles caractéristiques de Madagascar* (*Ammonites*). 64pp. Fascicule 9 (Aptien), Service Géologique, Tananarive.

Collignon M. 1965. Le Genre *Parachelonicera*s Coll., 1962 dans l' Aptien Supèrieur de Madagascar. *Comptes Rendus des Semaines Géologique*, *Tananarive*, 1965: 47–49.

Dimitrova N. 1967. *Fosilite na Balgariya. IV. Dolna Kreda-Glavonogo* (*Fossils of Bulgaria. IV. Lower Cretaceous-Cephalopoda* (*Nautiloidea and Ammonoidea*)). 424 pp. Bulgarian Academy of Sciences, Sofia. (in Bulgarian).

Douvillé H. 1890. Sur la classification des Cératites de la

Craie. *Bulletin de la Société Géologique de France* (*Series 3*), **18**: 275–292.

Drushchits V. V. 1956. *Lower Cretaceous ammonites from the Crimea and northern Caucasus*. 150 pp. Moskovskii Gosudarstvennyi Universitet.

Egoian V. L. 1965. Some ammonites from Clansayésien of Western Caucasus. *Transactions of Krasnodar Branch of Al-Unin Oil and Gas Scientific Insititute*, *issue* **1**, 112–160. (in Russian)

Egoian V. L. 1969. Ammonites from the Clansayan of the Western Caucasus. *Trudy Krasnodarskogo Filiala VNNII*, **19**: 126–317. (in Russian)

Eristavi M. S. 1955. *Lower Cretaceous fauna of the Georgia*. 224 pp. Institute of geology and mineralogy Academy of Science, GSSR. Monograph. no.6. (in Russian).

Eristavi M. S. 1961. Aptian and Albian ammonites of the northern Caucasus. *Transactions Geological Institute of Academy Science of Georgian SSR*, *ser. geology*, **12**: 41–77. (in Russian)

Etayo-Serna F. 1979. Zonation of the Cretaceous central Colombia by ammonites. *Publicaciones Geológicas Especiles del Ingeominas*, **2**: 1–188.

Fallot P. 1920. La faune des marnes aptiennes et albiennes de la région d' Andraitx (Majorque). *Trabajos del Museo Nacional de Ciencias Naturales*, *Serie Geologica*, **26**: 1–68.

Follmi K. B. 1989. Beschreibung neugefundener Ammonoidea aus der Vorarlberger Garschella-Formation (Aptian-Albian). *Jahrbuch der Geologiscehn Bundesanstalt*, **132**: 105–189.

Förster R. 1975. Die Geologische Entwicklung von Süd-Mozambique seit der Unterkreide und die ammoniten-fauna von Unterkreide und Cenoman. *Geologisches Jahrbuch*, B12: 3–324.

Fritel P. 1906. Sur les variations morphologiques d' *Acanthoceras milletianium* d'Orbigny sp. *Le Naturaliste*, **28** (472): 245–247.

Fujino S. and Maeda H. 2013. Environmental changes and shallow marine fossil bivalve assemblages of the Lower Cretaceous Miyako Group, NE Japan. *Journal of Asian Earth Sciences*, **64**: 168–179.

Fujino S., Masuda F., Tagomori S. and Matsumoto D. 2006. Structure and depositional processes of a gravelly tsunami deposit in a shallow marine setting: Lower Cretaceous Miyako Group, Japan. *Sedimentary Geology*, **187**: 127–138.

Gill T. 1871. *Arrangement of the Families of Mollusks*. xi+ 49 pp. Smithsonian Miscellaneous Collections 227.

Glazunova A. E. 1953. New subzone of the Albian deposits of Daghestan. *Transactions of All-Union Scientific Geological Institute*: 41–51. (in Russian)

González-León O., Patarroyo P., Moreno-Bedmar J. A., Nyborg T., Vega F. J. 2016. A new record and cuticular structure of *Meyeria magna* (Decapoda, Mecochiridae) from the lowr Albian (Lower Cretcaoues) of Colombia. *Cretaceous Research*, **57**: 342–349.

Grossouvre A. de 1894. Recherches sur la craie supérieure. Partie 2. Paléontologie. Les ammonites de la craie supérieure. *Mémoires du Service de la Carte Géologique détaillée de la France*: 1–264.

Haeckel E. 1866. *Allgemeine Entwicklungsgeschichte der Organismen*. 462 pp. Brlin (Reimer).

Haggart J. W. 1986. *Stratigraphic investigations of the Cretaceous Queen Charlotte Group*, *Queen Charlotte Islands*, *British Columbia*. Geological Survey of Canada, Paper 86-20, 24 pp., pl. 1.

Haggart J. W. 1991. A synthesis of Cretaceous stratigraphy, Queen Charlotte Islands, British Columbia. *In* Woodsworth G. J. ed. *Evolution and Hydrocarbon Potential of the Queen Charlotte Basin*, *British Columbia*: 253–277. Geological Survey of Canada Paper 90–10.

Hanai T., Obata I. and Hayami I. 1968. Notes on the Cretaceous Miyako Group. *Memoirs of the National Science Museum*, (1): 20–28. (in Japanese with English abstract)

Hayami I. 1966. Lower Cretaceous marine pelecypods of Japan Part III. *Memoirs of Faculty of Science, Kyushu University*, *Series D*, *Geology*, **17**: 151–249.

Hoffmann R., Howargth M. K., Fuchs D., Klug C. and Korn D. 2022. The higher taxonomic nomenclature of Devonian to Cretaceous ammonoids and Jurassic to Cretcaoues ammonites including their authorship and publication. *Neues Jahrbuch für Geologie und Paläontologie*, *Abhandlungen*, **305/2**: 187–197.

Hyatt A. 1889. *Genesis of the Arietidae*. xi+238 pp. Smithsonian Contributions to Knowledge, no. 673, Washington D. C.

Hyatt A. 1900. Cephalopoda. *In* Zittel K. A. ed. *Textbook of Palaeontology*, *1st English Edition*: 502–592. Translated by C. R. Eastman. Macmillan, London and New York.

Hyatt A. 1903. Pseudoceratites of the Cretaceous. *Monographs of the United States Geological Survey*, **44**: 1–352.

Humphrey W. E. 1949. Geology of Sierra de Los Muertos area, Mexico (with descriptions of Aptian cephalopods from the La Peña Formation). *Geological Society of America Bulletin*, **60**: 89–176.

Imlay R. W. 1960. Early Cretaceous (Albian) ammonites from the Chitina Valley and Talkeetna Mountains, Alaska. *U. S. Geological Survey Professional Papers*, **354-D**: 87–114.

Inose H., Maeda H. and Sashida K. 2013. Ammonoids from the Sakiyama Formation of the Lower Cretaceous Miyako Group, Iwate Prefecture, northeast Japan. *Bulletin of the National Science Museum of Nature and Science, Ser. C*, **39**: 43–50.

Ivanov M. 1993. Albian representatives of Lytoceratina Hyatt, 1889 in northwestern Bulgaria. *Geologica Balacania*, **23**: 45–64.

Jacob C. 1905. Étude sur les ammonites et sur I' horizon stratigraphique du gisement de Clansayes. *Bulletin de la Société Géologique de France* (*series 4*), **5**: 339–432.

Jacob C. and Tobler A. 1906. *Études stratigraphique et paleontologique du Gault de la valee de l'Engelberger Aa* (*Alpes calcaires suisses, environs du lac des Quatre Cantons*). 26pp. Memoires de la Société Paléontologique Suisse 33.

Karakasch 1907. Le crétacé inférieur de la Crimée et sa faune. *Travaux de la Société Impériale des Naturalistes de St.-Pétersburg*, *Section de Géologie et de Minéralogie*, **32**(5): 1–482.

Kase T. 1984. Early Cretaceous Marine and Brackish-water Gastropoda from Japan. *National Science Museum Monographs*, **1**: 1–189.

Kemper E. 1963. *Geologischer Fuher durch die Grafschaft Bentheim und die angrenzenden Gebiete*. 91 pp. Verlag Heimatverein der Grafschaft Bentheim, Nordhorn.

Kemper E. 1964. Einige Cephalopoden aus dem Apt des westlichen Norddeutschland. *In*: *Fortschritte in der Geologie von Rheinland und Westfalen 7. Die Kreide Westfalens*: 31–66.

Kemper E. 1975. Die cephalopoden aus dem unter-Alb (Zone der Leymeriella tardefurcata) von Altwarmbüchen. *Bericht der Naturhistorischen Gesellschaft zu Hannover*, **119**: 87–111.

Kennedy W. J. and Klinger H. G. 1978. Cretaceous faunas from Zululand and natal, south Africa, the ammonite Family Lytoceratidae Neumayr, 1875. *Annals of the South African Museum*, **74**: 257–333.

Kenndey W. J. and Klinger H. G. 1979. Cretaceous faunas from Zululand and Natal, South Africa, the ammonite Superfamily Haploceratacеae Zittel, 1884. *Annals of the South African Museum*, **77**: 85–121.

Kennedy W. K., Gale A. S., Bown P. R., Caron M., Gavey R., Gröcke D. and Wray D. S. 2000. Integrated stratigraphy across the Aptian-Albian boundary in the Marnes Bleues at the Col de Pré-Guittard, Arnayon (Drôme), and at Tartonne, Alpes-de-Haute-Provence, a candidate Global Boundary Stratotype Section and Boundary Point for the base of the Albian Stage. *Cretaceous Research*, **21**: 591–720.

Kitamura T., Matsukawa M., Obata I. and Matsumoto T. 1979. Geological age of the Todai Formation in the Akaishi Mountains, central Japan. *Memoirs of the National Science Museum*, *Tokyo*, (12): 55–64. (in Japanese with English summary)

Klein J. and Vašíček Z. 2011. *Lower Cretaceous ammonites V Desmoceratidae*. *Fossilium Catalogus I*: *Animalia, Herausgeber Wolfgang Riegraf pars 148*. 311 pp. Backhuys Publishers, Margraf Publishers GmbH, Weikersheim.

Koenen A. von 1902. Die Ammonitiden des norddeutschen Neocom (Valaginien, Hauterivien, Barrêmien und Aptien). *Abhandlungen der Königlichen Preussischen Geologischen Landesanstalt und Bergakademie zu Berlin* (*new series*), **24**, 1–449.

Kvantaliani I. V. 1972. Some new species from the Clansayésien of the Georgia. *Journal of the Georgian Geological Society*, *Academy of Sciences*, **8**(1, 2): 10–27.

Latil J. L. 2011. Early Albian ammonites from Central Tunisia and adjacent areas of Algeria. *Revue de Paleobiologie*, **30**: 321–429.

Lehmann J., Heldt M., Bachmann M. and Negra M. E. H.

2009. Aptian (Lower Cretaceous) biostratigraphy and cephalopods from north central Tunisia. *Cretaceous Research*, **30**: 895–910.

Lehmann J. and Murphy M. A. 2000. *Sanmartinoceras* aff. *walshense* (Etheridge, 1892) from the Early Cretaceous of California – the third evidence of the ammonite subfamily Aconeceratinae Spath, 1923 in North America. *Acta Geologica Pololonica*, **50**: 119–124.

Liu G. F. 1988. Late Jurassic and early Cretaceous ammonites from Nyalam Gucuo area, Xizang (Tibet). *In* Chinese Academy of geological sciences ed. *Professional papers of Xizang* (*Tibet*) *Paleontology*: 1–65. (in Chinese with English summary)

Marechal M. 1994. Les *Hypacanthoplites* Spath, 1923, des Argiles à Bucaillella cayeuxi de Cauville (76) et leur position stratigraphique. *Bulletin de la Sociéte géologique de Normandie et Amis Muséum du Havre*, **81**: 83–96.

Matsukawa M. 2021. Aptian (Lower Cretaceous) ammonite fauna of the Todai Formation, Nagano Prefecture, Japan. *Cretaceous Research*, **126**: October 2021, 104771.

Matsukawa M. and Oji T. 2022. Aptian (Lower Cretaceous) ammonite assemblages of the Miyako Group in the Taro area, Miyako City, Northeast Japan. *Bulletin of Tokyo Gakugei University*, *Division of Natural Sciences*, **74**: 141–162.

Matsukawa M., Sendon S. V., Mateer F. T. Sato T. and Obata I. 2012. Early Cretaceous ammonite fauna of Catanduanes Island, Philippines. *Cretaceous Research*, **37**: 261–271.

Matsumoto T. 1955. Family Kossmaticeratidae from Hokkaido and Saghalien. *Japanese Journal of Geology and Geography*, **26**: 115–164.

Matsumoto T. 1959. Cretaceous ammonites from the upper Chitina Valley, Alaska. *Memoirs of the Faculty of Science*, *Kyushu University*, *Series D, Geology*, **8** (3): 49–90.

Matsumoto T., 1984. A gigantic Parahoplitid ammonite from northern Hokkaido. *Report of the Geological Survey of Hokkaido*, (55): 21–28.

Matsumoto T., Kanmera K. and Sakamoto H. 1968. Notes on two Cretaceous ammonites from the Tomochi Formation of Kyushu. *Japanese Journal of Geology and Geography*, **39**: 139–148.

Matsumoto T., Takahashi T., Kawashita Y., Muramoto K., Kera M., Kera Y., Shimanuki T., Yamashita M. and Kokubun H. 1988. *A monograph of the Puzosiidae* (*Ammonoidea*) *from the Cretaceous of Hokkaido*. 179 pp. Palaeontological Society of Japan, Special Papers 30.

Matsumoto T. and Murakami K. 1991. Description of a *Marshallites* species from the Tomochi Formation in southwest Japan. *In* Matsumoto T. compiler *The mid-Cretaceous ammonites of the Family Kossmaticeratidae from Japan, Part V*: 129–131. Palaeontological Society of Japan, Special Papers 33.

Matsumoto T. and Tamura M. 1968. Record of an ammonite from the Shimano Belt of the Kuma area, Kyushu. *Proceeding of Japan Academy Series B*, **58**: 148–151.

Matsumoto T., Takahashi T., Saito R. and Sanada K., 1991. Part II Description of the species from Hokkaido, excluding the Shumarinai-Soeushinai area. *In* Matsumoto T. compiler *The Mid-Cretaceous ammonites of the Family Kossmatidae from Japan*, *Part V*: 21–102. Palaeontological Society of Japan, Special papers 33.

Mikhailova I. A. 1963. On the systematic position and extent of the genus *Diadochoceras*. *Paleontological Journal*, **3**: 65–77.

Moreno-Bedmar J. A., Company M., Sandoval J., Tavera J. M., Bover-Arnal T., Salas R., Delanoy G., Maurrasse F.J.-M.R. and Martínez R. 2012. Lower Aptian ammonite and carbon isotope stratigraphy in the eastern Prebetic Domain (Betic Cordillera, southeastern Spain). *Geologica Acta*, **10**(4): 333–350

Murphy M. A. 1956. Lower Cretaceous stratigraphic units of northern California. *American Association of Petroleum Geology Bulletin*, **40**: 2098–2119.

Murphy M. A., 1967. Aptian and Albian Tetragonitidae (Ammonoidea) from northern California. *University of California Publications in Geological Sciences*, **70**: 1–43.

Obata I. 1967. Lower Cretaceous ammonites from the Miyako Group, Part 2 some silesitids from the Miyako Group. *Transactions and Proceedings of the Palaeontological Society of Japan*, *New Series*, (67): 129–138.

Obata I. 1969. Lower Cretaceous ammonites from the Miyako Group, Part 3. Some douvilleiceratids from the Miyako Group. *Transactions and Proceedings of the Palaeontological Society of Japan*, *New Series*, (76): 165–176.

Obata I. 1973. Lower Cretaceous ammonites from the Miyako Group, Part 4, *Pseudoleymeriella* from the Miyako Group. *Science Report of the Tohoku University*, *Second Series* (*Geology*), *Special Volume*, **6** (Hatai Memorial Volume): 309–314.

Obata I. 1975. Lower Cretaceous ammonites from the Miyako Group, Part 5. *Diadochoceras* from the Miyako Group. *Bulletin of the National Science Museum*, *Tokyo*, *series C* (*Geology*), **1**: 1–10.

Obata I. and Futamaki M. 1991. The mid-Cretaceous ammonites of the Family Kossmaticeratidae from Japan, Part 4. A new *Marshallites* species from the Miyako Group in northeast Japan (Lower Cretaceous Ammonites from the Miyako Group, Part 7). *Palaeontological Society of Japan*, *Special Papers*, (33): 123–128.

Obata I. and Futakami M. 1992. Some selected ammonites from the Aptian and Albian Miyako Group, Japan. *Bulletin of the National Science Museum*, *Ser. C*., **18**(3): 79–99.

Obata I. and Matsukawa M. 1980. Ontogeny and variation in *Hypacanthoplites subcornuerianus*, a Lower Cretaceous hoplitid ammonite (Lower Cretaceous ammonites from the Miyako Group, Part 6). *Prof. Saburo Kanno Memorial Volume*: 185–211.

Obata I. and Matsukawa M. 2009. Some ammonoids from the Barremian and probable Albian of the Choshi Peninsula, Japan. *Bulletin of Tokyo Gakugei University*, *Division of Natural Science*, **61**: 97–103.

Obata I. and Matsukawa M. 2013. A review of the Cretaceous Raga Formation of the Miyako Group, and its related rocks in Japan. *Report of Fukada Geological Institute*, (14): 57–65.

Obata I. and Matsukawa M. 2018. Aptian and Albian ammonites of the Miyako Group, Japan (Lower Cretaceous ammonites of the Miyako Group, Part 11). *Cretaceous Research*, **88**: 227–272.

Orbigny A. d' 1840. *Paléontologie française. Description Zoology et Géologique de tous Les Animaux Mollusques et Rayonnés Fosssisiles de France*. 662 pp. Cosson, Paris.

Parona C. F. and Bonarelli G. 1897. Fossili Albiani d' Escragnolles del Nizzardo e della Liguria occidentale. *Palaeontographia Italica*, **2** (1896): 53–112.

Raisossadat S. N. 2006. The ammonite family Parahoplitidae in the Sangabeh Formation of the Kopet Dagh Basin, north-eastern Iran. *Cretaceous Research*, **27**: 907–922.

Reboulet S., Szives O., Aguirre-Urreta B., Barragán R., Company M., Frau C., Kakabadze N. V., Klein J., Moreno-Bedmar J. A., Lukeneder A., Pictet A., Ploch I., Raisossadat S. N., Vašíček Z., Baraboshkin E. J. and Mitta V. V. 2018. Report on the 6th International Meeting of the IUGS Lower Cretaceous Ammonite Working Group, the Kilian Group (Vienna, 20th Austria 2017). *Cretaceous Research*, **91**: 100–110.

Renz O. 1982. *The Cretaceous ammonites of Venezuela*. 132 pp., 40 pls. Birkhäuser Verlag, Basel, Boston, Suttgart.

Riccardi A. C., Aguirre Urreta, M. B. and Medina F. A. 1987. Aconeceratidae (Ammonitina) from the Hauterivian – Albian of southern Patagonia. *Palaeontographica A,* **196**: 105–185.

Riccardi A. C. and Medina F. A. 2002. The Beudanticeratinae and Cleoniceratinae (Ammonitida) from the Lower Albian of Patagonia. *Revue de Paléobiologie*, **21** (1): 291–351.

Riedel L. 1938. Amonitas del cretacico inferior de la Cordillera Oriental. *Estudios Geologicos y Paleontologicos sobre la Cordillera Priental de Colombia, part 2*: 7–78.

Rodda P. U. and Murphy M. A. 1992. Two occurrences of the genus *Pictetia* (Early Cretaceous, Albian, Ammonoidea) in California. *Journal of Paleontology*, **66**: 435–439.

Ropolo P., Moullade M., Gonnet R., Conte G. and Tronchetti G. 2008. *The Douvilleiceratida* (*Ammonoidea*) *of the Lower Aptian historical stratotype at Cassis-La Bedoule* (*SE France*). 60pp. Carnets de Geologie / Notebooks on Geology, Brest, Memoir 2008/03 (CG2008_M03).

Rouchadzé J. 1938. Les ammonites aptiennes du Caucase du Nord. *Bulletin du Musée d'État de Géorgie*, **9A**: 113–209.

Samaniego-Pesqueira A., Moreno-Bedmar J. A. and Álvarez-Sánchez L. F. 2021. Upper Aptian ammonite biostratigraphy of the Agua Salada and Mural formations, Sonora State, northwest Mexico. *Journal of South American Earth Sciences*, **112**: December 2021, 103558.

Sarasin M. C. 1893. Étude sur les Oppelia du group du Nisus et les Sonneratia du groupe du Bicurvatus et du Raresulcatus. *Bulletin de la Société Géologique de France, ser*, *3*, **21**: 149–164.

Saveliev A. 1973. Stratigraphy and ammonites of the Lower Albian of Mangyshalk. *Trudy Vsecoiuznogo Nauchno-Issledovatel'skogo Geologicheskogo Neftegazovogo Instituta*, **323**: 1–339 (in Russian).

Scott G. 1940. Cephalopods from the Cretaceous Trinity Group of the south-central United States. *The University of Texas Publications*, **3945**: 969–1107.

Shimazu M., Tanaka K. and Yoshida T. 1970. *Geology of the Taro district*. 54 pp. Quadrangle series, scale 1:50,000. Geological Survey of Japan. (in Japanese with English abstract)

Shimizu S. 1931. The marine Lower Cretaceous deposits of Japan, with special reference to the ammonite-bearing zones. *Science reports of the Tohoku Imperial University*, *2nd series*, *Geology*, **15**: 1–40.

Sinzow I. T. 1907. Untersuchungen einiger Ammonitiden aus dem Unteren Gault Mangyshlaks und des Kaukasus. *Verhandlungen der russisch-kaiserlichen Mineralogischen Gesellschafz zu St. Petersburg*, **45**: 455–519.

Spath L. F. 1922. On the Senonian ammonite fauna of Pondoland. *Transactions of the Royal Society of South Africa*, **10**: 113–148.

Spath L. F. 1923. A monograph of the Ammonoidea of the Gault, Part 1. *Palaeontolographical Society* (*1921*) *London*: 1–72.

Spath L. F. 1927. Revision of the Jurassic Cephalopod fauna of Kachh (Cutch), [part 1]. *Memoirs of the Geological Survey of India*, *Palaeontologia Indica*, *New Series*, **9**, memoir, (2): 1–71 pls. i-vii.

Stoyanow A. 1949. Lower Cretaceous stratigraphy in southeastern Arizona. *Geological Society of America Memoir*, **38**: 1–170.

Szives O. 2007. Aptian–Campanian ammonites of Hungary. *Geologica Hungarica*, *series Palaeontologica Fasciculus*, **57**: 1–183.

Tanaka K. 1978. The Miyako Group as treasure trove of Lower Cretaceous fossils. *Chishitsu News*, (291): 32–48. Geological Survey of Japan. (in Japanese)

Tanaka K. and Obata I. 1982. Selected echinoid fossils from the Miyako Group (Lower Cretaceous), Northeast Honshu, Japan. *Bulletin of Natural Science Museum*, *Series C* (*Geology*) , **8**: 117–143.

Tavani G. 1949. Fauna malacologica cretacea della Somalia e dell' Ogaden. Parte Seconda. Gastropoda – Cephalopoda – Conclusioni. *Palaeontographia Italica*, **45** (new series, 15): 1–76.

Thomson M. R. A. 1974. Ammonite faunas of the Lower Cretaceous of south-eastern Alexander Island. *British Antarctic Survey Scientific Report*, **80**: 1–44.

Toshimitsu S. and Hirano H. 2000. Database of the Crtaceous ammonoids in Japan – stratigraphic distribution and bibliography. *Bulletin of the Geological Survey of Japan*, **51**: 559–613.

Uhlig V. 1883. Die Cephalopodenfauna der Wernsdorfer Schichten. *Denkschriften der kaiserlichen Akademie der Wissenschaften zu Wien*, *Mathematisch-Naturwissenschaftliche Klasse*, **46**: 127–290 [1–166].

Urakawa R., Komatsu T., Takashima R., Omatsu K. and Nishi H. 2016. Benthic foraminifers and depositional environments of the Lower Cretaceous Miyako Group on Hideshima Island, Miyako area, Iwate Prefecture, northeast Japan. *Journal Geological Society of Japan*, **123**: 121–130. (in Japanese with English abstract)

Urmanova S. KH. 1962. A new ammonite species from the Lower Cretaceous deposits of Turkmenia. *Paleontologicheskii Zhurnal*, **2**: 76079.

Vašíček Z. 1973. Uber einiger von V. Uhlig (1883) beschriebene Unterkreide - Ammoniten. Sbornik Geologickych ved. *Paleontologie*, **15**: 49–74.

Vašíček Z., Michalík J. and Reháková D. 1994. *Lower Cretaceous stratigraphy*, *paleogeography and life in Western Carpathians*. 170 pp. Beringeria 10.

Wassiliewski M. 1908. Note sur les couches à Douvilleiceras dans les environs de la ville de Saratov. *Travaux du Musée Géologique Pierre le Grand près l'Académie Impériale des Sciences de St Petersbourg*., **2**, Issue 2: 29–51 (in Russian).

Whiteaves J. F. 1893. Description of two new species of Ammonites from the Cretaceous rocks of the Queen

Charlotte Islands. *Canadian Record of Science*, 441–446.

Whitehouse F. W. 1926. The Cretaceous Ammonoidea of eastern Australia. *Memoirs of the Queensland Museum*, **8**: 195–242.

Wiedmann J. 1962. Ammonites du Crétacé inferieur de Majorque (Baléares), 1. Partie: Lytoceratina et Aptychi. *Bolletin de la Sociedad de Historia natural de Balaerres*, **8**: 1–54.

Wiedmann J. 1966. Stammesgeschichte und System der posttriadischen Ammonoideen, ein Überblick (2. Teil). *Neues Jahrbuch für Geologie und Paläontologie*, *Abhandlungen*, **127**: 13–81.

Wright C. W., Calloman, J. H. and Howarth M. K. 1996. Cretaceous Ammonoidea. *In* Brousius E., Hardesty J., Keim J., Kerns J. and Renteria K. eds. *Treatise on Invertebrate Paleontology*, *Part L. Mollusca 4* (*revised*). xx + 362 pp. The Geological Society of America, Boulder, and The University of Kansas Press, Lawrence.

Yabe H. and Yehara S. 1913. The Cretaceous deposits of Miyako. *Science Report of the Tohoku Imperial University*, *2nd series*, **1**: 9–24.

Zeiss A. 1975. The Aptian ammonite fauna of Ethiopia: new result on the biostratigraphy and zoogeography. *Neues Jahrbuch für Geologie und Palaeontologie*, *Monatsshefte*, **10**: 628–639.

Zittel K. A. von 1884. Cephalopoda. *In* Zittel K. A. ed. *Handbuch der Palaeontologie*, *Band 1, Abt. 2*, *Lief 3*: 329–522. Oldenbourg, Munich and Leipzig.

Zittel K. A. 1895. *Grundzüge der Palaeontologie*. viii+971 pp. Oldenboug, Munich and Leipzig.