Paleontological Research, vol. 1, no. 1, pp. 55-66, 9 Figs., April 30, 1997

5. Permian cephalopods of Kurosawa, Kesennuma City in the Southern Kitakami Massif, Northeast Japan

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Received 4 July 1996; Revised manuscript accepted 22 December 1996

Abstract. **Permian nautiloids and ammonoids are described from the middle part of the Ochiai Formation distributed in the Kurosawa district of northern Kesennuma City, Southern Kitakami Massif, Northeast Japan. The nautiloids are *Tainoceras, Pleuronautilus* and *Stearoceras*. One new species, *Tainoceras carinatum,* is proposed. The ammonoids are *Jilingites, Stacheoceras, Timorites, Pseudagathiceras, Propinacoceras* and *Eumedlicottia. Jilingites kesennumensis, Timorites takaizumii* and *Pseudagathiceras ornatum* are newly proposed species. Based on the stratigraphic distribution of *Timorites, Jilingites* and *Pseudagathiceras,* and the stratigraphic relationship between the cephalopod horizon and *Lepidolina*-bearing limestones, the cephalopod-bearing formation of Kurosawa is considered to be correlatable with the upper Capitanian.**

Key words: Capitanian, *Helicoprion,* Kesennuma, Kitakami Massif, Permian cephalopod

Introduction

Permian strata are widely distributed in the northern district of Kesennuma City, Southern Kitakami Massif, forming a large synclinorium, the axis of which trends NS and plunges to the south. They are divided into the Nakadaira, Ochiai and Nabekoshiyama Formations, in ascending order (Ehiro, 1977). These formations are roughly correlated with the Lower Permian Sakamotozawan Series, Middle Permian Kanokuran Series to the middle part of the Upper Permian Toyoman Series, and upper Toyoman Series, respectively. They have been studied stratigraphically and paleontologically for 100 years, and many Middle Permian brachiopods and molluscs have been described from the upper part of the lower Ochiai Formation. Uppermost Permian fossils such as *Colaniella parva* and *Palaeofusulina* sp., in association with brachiopods and pelecyoods, have also been found (Tazawa, 1975; Ishii *et al.*, 1975) from the Nabekoshiyama Formation.

Araki (1980) reported the occurrence of a chondrichthyes, *Helicoprion* sp., from sandy shale of the middle part of the Ochiai Formation, which crops out at a tributary of the Kurosawa River in the Kamiyasse district, northern Kesennuma. He also collected some cephalopods from a horizon slightly lower than that of *Helicoprion.* These horizons were correlated with the upper part of the Kanokuran Series based on a preliminary study of the cephalopod fauna (Araki, 1980). The upper Kanokuran Series is generally correlated with the upper Maokouan of South China and with the Capitanian of North America. These cephalopods, however, have not been described previously, nor have been known other index fossils near the fossil locality.

Recently, the present authors studied stratigraphically the Permian strata in and around the Kurosawa River and collected some additional cephalopods from Araki's locality and other new localities with the assistance of Yukihiro Takaizumi. The present paper describes the cephalopods from the middle part of the Ochiai Formation distributed in the catchment area of the Kurosawa River and discusses the age of the fauna.

Geologic settings

The Ochiai Formation in the Kamiyasse district is composed mainly of shales, except for the upper part of the lower part (Toyazawa Member). In this member, distributed in the upper tributaries of the Shigejizawa River (Figure 1), sandstones and impure limestones predominate. It yields diverse fossils such as fusulinids, brachiopods, bryozoans, crinoids and molluscs. *Monodiexodina matsubaishi* (Fujimoto), which is a characteristic fusulinid of the lower part of the Kanokuran Series, dominates in the lower to middle part of the member. The upper part of the member yields such fusulinids as *Verbeekina, Pseudodoliolina* and *Lepidolina* (Tazawa, 1976), which characterize the upper Kanokuran.

The middle part of the Ochiai Formation, consisting mainly of massive sandy shales and shales with rare thin sandstone interbeds, is widely distributed in the Kurosawa River and its tributaries. In a horizon about 400 m above the top of the Toyazawa Member, thin lenticular limestones with maximum

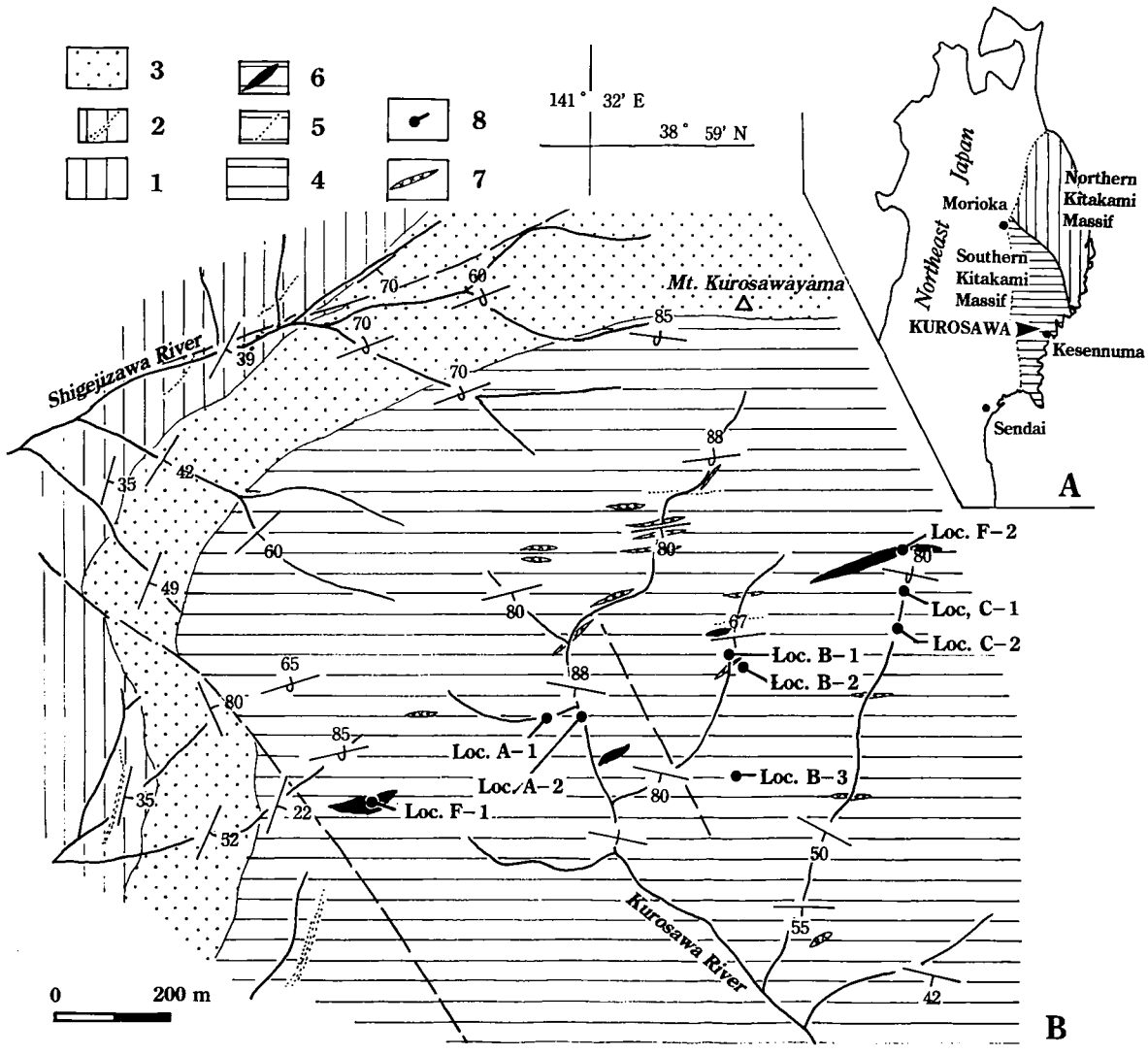


Figure 1. Index map (A) and geologic map of the Kurosawa district, northern Kesennuma, Southern Kitakami Massif, Northeast Japan (B). **1-2.** lower part of the Ochiai Formation (1: shale, 2: sandstone). **3.** Toyazawa Member of the Ochiai Formation (sandstone, limestone, shale and conglomerate). **4-6.** middle part of the Ochiai Formation (4: shale, 5: thin sandstone, 6: limestone). **7.** porphyrite. **8.** fossil localities.

thicknesses of 5 to 20 meters are intercalated at some localities (Figure 1B). They yielded fusulinids, *Lepidolina* sp. (Loc. F-1 in Figure 1B) and *Verbeekina* sp. (Loc. F-2). The relationships between these limestone lenses and surrounding shales is uncertain. The latter are not calcareous. This points to a possibility that these limestone lenses are not *in situ* but are exotic blocks derived likely from lower horizons.

Shales in the middle part of the Ochiai Formation are almost barren of fossils, but some cephalopods, together with a few brachiopods and gastropods, have been collected at some localities (Loc. A-1 to C-2 in Figure 1B). Among these are Loc. B-1 and B-2 which yielded abundant cephalopods. Examination led to the discrimination of the following forms.

Locality A-1: *Propinacoceras* sp.

Locality A-2: *Eumedlicottia primas* (Waagen)

Locality B-1: *Tainoceras carinatum* sp. nov., *Pleuronautilus* sp., *Jilingites kesennumensis* sp. nov., *Timorites takaizumii* sp. nov., *Pseudagathiceras ornatum* sp. nov., *Propinacoceras* sp.

Locality B-2: *Tainoceras* sp., *Pleuronautilus* sp., *Stacheoceras* sp., *Timorites*? sp., *Propinacoceras* sp., *Eumedlicottia primas* (Waagen)

Locality B-3: *Stearoceras* sp.

Locality C-1: *Timorites takaizumii* sp. nov.

Locality C-2: *Tainoceras* sp.

Ammonoid locality A-1 is stratigraphically about 100 m lower than that of *Lepidolina*-bearing lenticular limestone. The ammonoid *Eumedlicottia* from Loc. A-2 at a horizon

about 20 m higher than that of Loc. A-1 was collected from a large loose shale block on the river bed. Cephalopod horizons at Loc. B-1, B-2 and B-3 are about 80-90, 110-120 and 300 m above the limestone lenses, respectively. The locality of *Helicoprion* is near Loc. B-2 and is stratigraphically 30-40 m higher than that of the latter. Cephalopods of Loc. C-1 and C-2 were both collected from floats on the river floor, possibly derived from shales little above *Verbeekina*-bearing limestone.

Faunal consideration

The cephalopod fauna of Kurosawa comprises three genera of nautiloids and six of ammonoids. *Timorites* is abundant in the fauna and more than 20 specimens are at hand. *Propinacoceras* is the next most common. Specimens of the other genera are rarer, one to four specimens each. *Jilingites* and *Pseudagathiceras* are described here from Japan for the first time.

Cephalopod genera of Kurosawa, except for *Jilingites, Timorites* and *Pseudagathiceras,* have rather long stratigraphic ranges. *Jilingites bidentus* Liang, which is the type species and only known representative of the genus, occurs in the Middle Permian (Wordian) Fanjiatun Formation of Jilin, North China (Liang, 1982). The Kurosawa species of *Jilingites* is closely similar to the Chinese species.

Species of *Timorites* are characteristic of the Permian ammonoid Equatorial Provinces (Ehiro, 1996), and have been reported from the upper Middle Permian (Capitanian) formations in the Tethyan province from such places as Timor, Japan, Far Eastern Russia, South China and the Himalayan region of China, and Texas, U.S.A, and Coahuila, Mexico, in North America. They are also known from Upper Permian Dzhulfian formations in the Kitakami Massif (Ehiro *et al.*, 1986), Transcaucasia and Central Iran (Zhou *et al.* 1989).

According to Miller (1944), five species of *Pseudagathiceras* are known from Wordian formations of Timor, Sicily and Coahuila. The Kurosawa species of *Pseudagathiceras* closely resembles the Coahuila species in the shape of shells and the presence of prominent ventrolateral spines.

Based on the occurrence of *Timorites,* the ammonoid-bearing horizons of Kurosawa, especially B-1 and B-2, are correlatable with somewhere in the interval from the Capitanian to Dzhulfian. On the other hand, the associated *Jilingites* and *Pseudagathiceras* suggest that the age of the fauna is not younger than Wordian, although their stratigraphic ranges are less certain. The horizons of B-1 and B-2 are a little higher than those of limestone lenses, which yield Capitanian fusulinids such as *Lepidolina* and *Verbeekina,* although there is a possibility that the limestone lenses are not *in situ*. No typical Dzhulfian ammonoids, such as araxoceratids and advanced xenodiscids, have been collected from these horizons. Therefore, the age of the cephalopod fauna and of *Helicoprion* sp. from Kurosawa is considered to be late Capitanian as presumed by Araki (1980), not Dzhulfian.

Systematic description

Specimens described in this paper are kept in the Institute of Geology and Paleontology, Tohoku University, Sendai (IGPS).

Subclass Nautiloidea Agassiz, 1847
Order Nautilida Agassiz, 1847
Superfamily Tainocerataceae Hyatt, 1883
Family Tainoceratidae Hyatt, 1883
Subfamily Tainoceratinae Hyatt, 1883
Genus ***Tainoceras*** Hyatt, 1883

Type species.—*Nautilus quadrangulus* McChesney, 1868

Tainoceras carinatum sp. nov.

Figures 3-2a, b

Material.—A fragmentary specimen, IGPS coll. cat. no. 103114, collected from Loc. B-1 by Y. Takaizumi.

Diagnosis.—*Tainoceras* having lateral ribs and carinated ventrolateral shoulders.

Descriptive remarks.—About one third of the outer volution, the diameter of which is estimated to attain 45 mm, was examined. The conch is thickly discoidal and evolute in outline, with a large and deep umbilicus. It is slightly wider than high, and has flat sides, which very slightly converge toward the broadly rounded venter. The umbilical shoulder

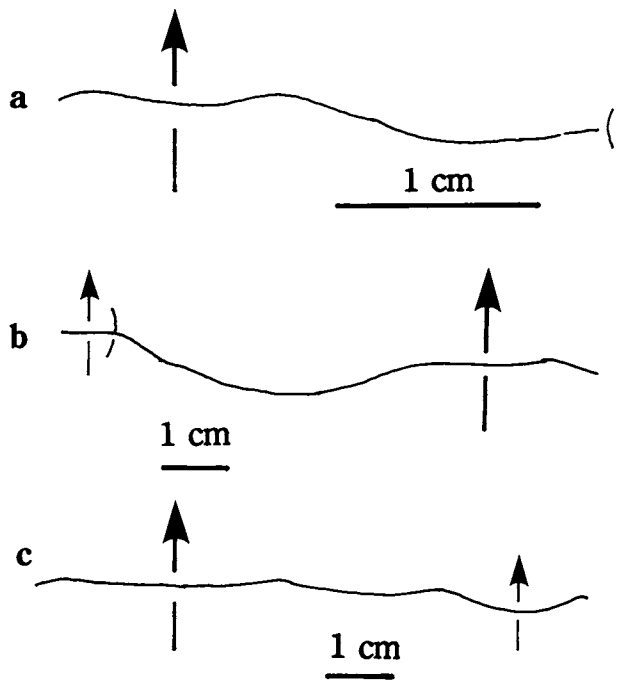


Figure 2. Suture lines of nautiloids from the Ochiai Formation. **a.** *Tainoceras* sp., IGPS coll. cat. no. 103115. **b.** *Pleuronautilus* sp., IGPS coll. cat. no. 103116. **c.** *Stearoceras* sp., IGPS coll. cat. no. 103118.

is acutely rounded and ventral shoulder is edged with a fine keel. The flanks have rather fine but strong radial ribs, which are straight throughout their length. They extend from the umbilical to ventral shoulder and are nodose at the ventral end. There are two rows of nodes, which characterize the genus *Tainoceras,* on the venter. The suture is unknown.

In having straight and fine lateral ribs, the present species somewhat resembles *Tainoceras noetlingi* Frech (Frech, 1911, p. 106, pl. 16, fig. 1) and *T. noetlingi subglobosa* Reed (Reed, 1931, p. 51, pl. 7, fig. 5) from the Salt Range and *T. orientale* (Kayser) from South China (Kayser, 1883, p. 163, pl. 14, fig. 2). The Kurosawa species, however, has a larger umbilicus than the Salt Range and Chinese species. Moreover, the carinated ventral shoulders, though the keels are very fine, are unique in the present species and distinguishes it from all

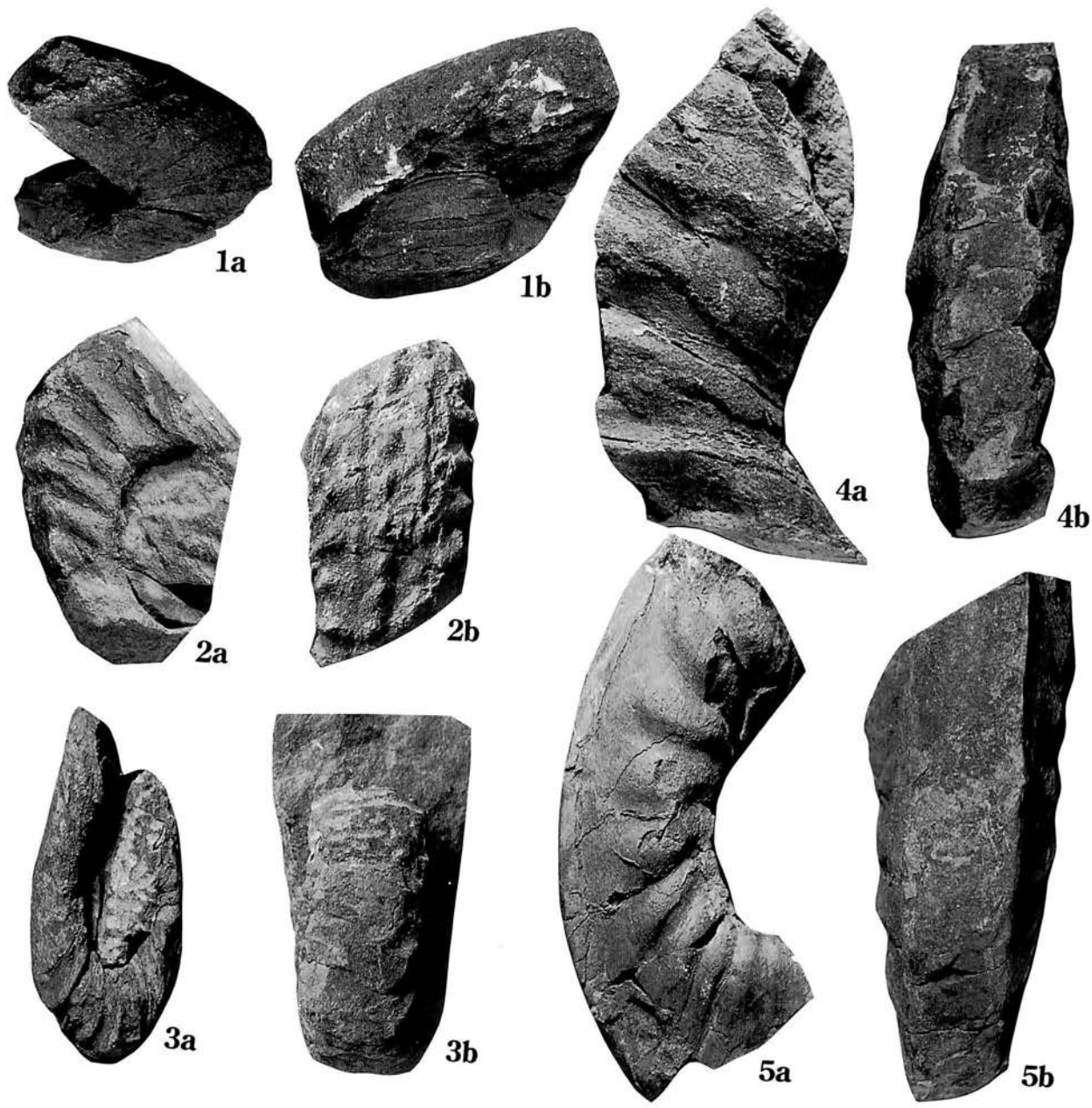


Figure 3. Nautiloids from the Ochiai Formation. **1.** *Stearoceras* sp., IGPS coll. cat. no. 103118, lateral (a) and ventral (b) views, ×0.9. **2.** *Tainoceras carinatum* sp. nov., IGPS coll. cat. no. 103114 (Holotype), lateral (a) and ventral (b) views, ×1.1. **3.** *Tainoceras* sp., IGPS coll. cat. no. 103115, lateral (a) and ventral (b) views, ×1. **4, 5.** *Pleuronautilus* sp., 4 : IGPS coll. cat. no. 103117, lateral (a) and ventral (b) views, ×0.65, 5 : IGPS coll. cat. no. 103116, lateral (a) and ventral (b) views, ×0.75.

other species of the genus *Tainoceras.*

Etymology.—From the carinated form of the ventrolateral shoulders.

Tainoceras sp.

Figures 2-a; 3-3a, b

Material.—A deformed specimen, IGPS coll. cat. no. 103115, collected from Loc. C-2 by M. Ehiro.

Description.—The conch is flattened dorsoventrally due to tectonic deformation. It is moderately evolute and may be thickly discoidal in outline. The whorl section is subrectangular with broadly rounded sides which converge toward the convex venter. The flanks bear radial ribs extending from the umbilical to ventral shoulder. There is a pair of rows of nodes on the venter, though not so visible owing to tectonic flattening.

The suture is simple and nearly straight, but with a shallow and wide lateral lobe.

Subfamily Pleuronautilinae Hyatt, 1890
Genus ***Pleuronautilus*** Mojsisovics, 1882

Type species.—Pleuronautilus trinodosus Mojsisovics, 1882

Pleuronautilus sp.

Figures 2-b; 3-4, 5

Materials.—Two fragmental specimens, IGPS coll. cat. no. 103116, collected at Loc. B-1 by M. Ehiro, and IGPS coll. cat. no. 103117, at Loc. B-2 by H. Araki.

Descriptive remarks.—The conch attains more than 100 mm in diameter. It is evolute and considered to be thickly discoidal in outline with a large and deep umbilicus. The umbilical wall is steep and umbilical shoulder is acutely rounded. The flat to slightly convex sides converge toward the venter. The wide venter is flat and the ventral shoulder is edged. The cross section of the conch is subtrapezoidal. The flanks are ornamented with broad and strong radial ribs. They extend from the umbilical wall to the outer third of the flank or to the ventral shoulder, and are widest and highest just above the umbilical shoulder. The suture consists of a very shallow ventral lobe, a small ventrolateral saddle and a wide and shallow lateral lobe.

Broad and strong ribs on the flanks are unique in the present species, but the material is too incomplete to represent any type of taxa.

Superfamily Trigonocerataceae Hyatt, 1884
Family Grypoceratidae Hyatt in Tittel, 1900
Genus ***Stearoceras*** Hyatt, 1893

Type species.—Endolobus gibbosus Hyatt, 1891

Stearoceras sp.

Figures 2-c; 3-1a, b

Material.—One specimen, IGPS coll. cat. no. 103118, collected from Loc. B-3 by M. Ehiro.

Description.—The specimen is involute in outline, with an almost closed umbilicus. It attains a diameter of more than 50 mm. The side of it is broadly rounded and the venter is slightly convex with rounded ventral shoulders. The cross section of the whorl is subtrapezoidal and depressed dorsoventrally in outline, but its depressed form is partly due to tectonic flattening. The surface of the conch is smooth. The suture lines are simple, forming a broad and shallow ventral lobe, a low ventrolateral saddle and a broad and shallow lateral lobe. The dorsal lobe is somewhat deep

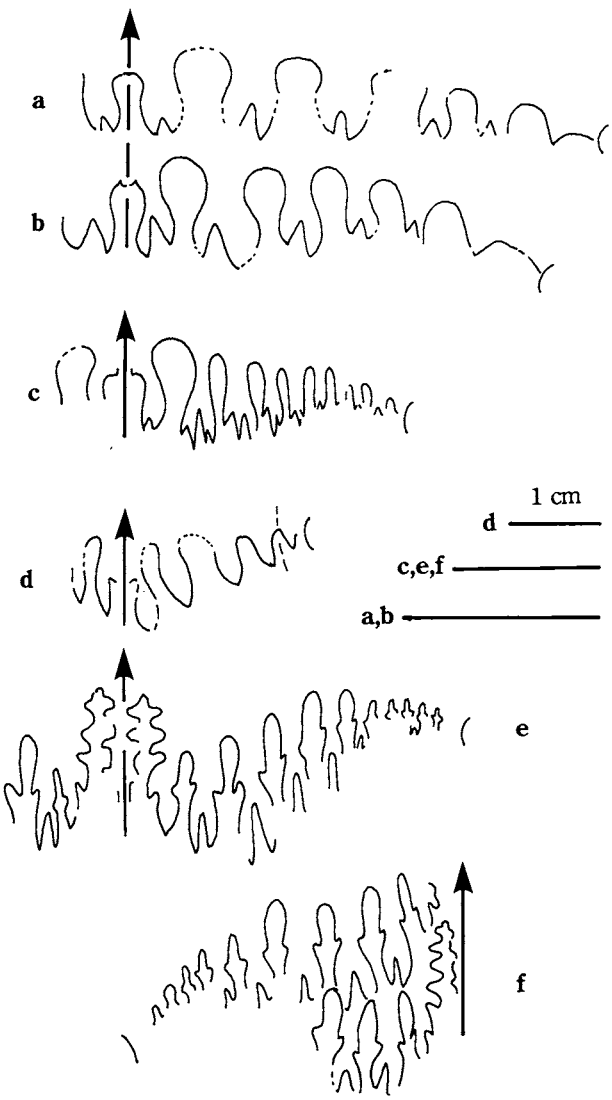


Figure 4. Suture lines of *Jilingites, Stacheoceras, Pseudagathiceras* and *Eumedlicottia* from the Ochiai Formation. **a, b.** *Jilingites kesennumensis* sp. nov., a: IGPS coll. cat. no. 103119 (Holotype), b: IGPS coll. cat. no. 103121. **c.** *Stacheoceras* sp., IGPS coll. cat. no. 103123. **d.** *Pseudagathiceras ornatum* sp. nov., IGPS coll. cat. no. 103136. **e, f.** *Eumedlicottia primas* (Waagen), e: IGPS coll. cat. no. 103142, f: IGPS coll. cat. no. 103143.

compared with the others.

Subclass Ammonoidea Agassiz, 1847
Order Goniatitida Hyatt, 1884
Suborder Goniatitina Hyatt, 1884
Superfamily Marathonitaceae Ruzhentsev, 1938
Family Marathonitidae Ruzhentsev, 1938
Subfamily Jilingitinae Liang, 1982
Genus ***Jilingites*** Liang, 1982

Type species.—*Jilingites bidentus* Liang, 1982

Jilingites kesennumensis sp. nov.

Figures 4-a, b ; 5-1, 4, 5

Materials.—Holotype : IGPS coll. cat. no. 103119, collected from Loc. B-1 by Y. Takaizumi. Paratypes : IGPS coll. cat. no. 103120, by Y. Takaizumi and IGPS coll. cat. no. 103121, by M. Ehiro, both from Loc. B-1, and IGPS coll. cat. no. 102122, from Loc. B-2 by H. Araki.

Diagnosis.—*Jilingites* with a small but deep umbilicus. The surface of the living chamber is ornamented by fine radial growth lines.

Description.—The shell is involute and thickly lenticular in outline. It is moderately large and attains a diameter of 54 mm. The umbilicus with a steep umbilical wall is small but deep. The sides of the conch are broadly convex and converge towards the venter. The venter is broadly rounded, but acutely rounded on the adoral part of the body whorl. The whorl cross section is subtriangular, with rounded umbilical and ventral shoulders. The surface of the phragmocone may be smooth, but on the living chamber of the holotype there are faint sigmoidal growth lines.

The suture consists of a broad bifid ventral lobe, four bifid lateral lobes and a pointed small umbilical lobe on the umbilical shoulder. All saddles are rounded.

Comparison.—The Kitakami species of *Jilingites* closely resembles *J. bidentus* Liang (Liang, 1982, p. 651, text-figs. 6a-b, pl. 1, figs. 10-13) reported from the Wordian Fanjiatun Formation of Jilin, North China in the shape of the conch and suture. The former, however, differs from the latter in having a deeper umbilicus and ornamented living chamber.

Etymology.—The specific name is derived from Kesen-

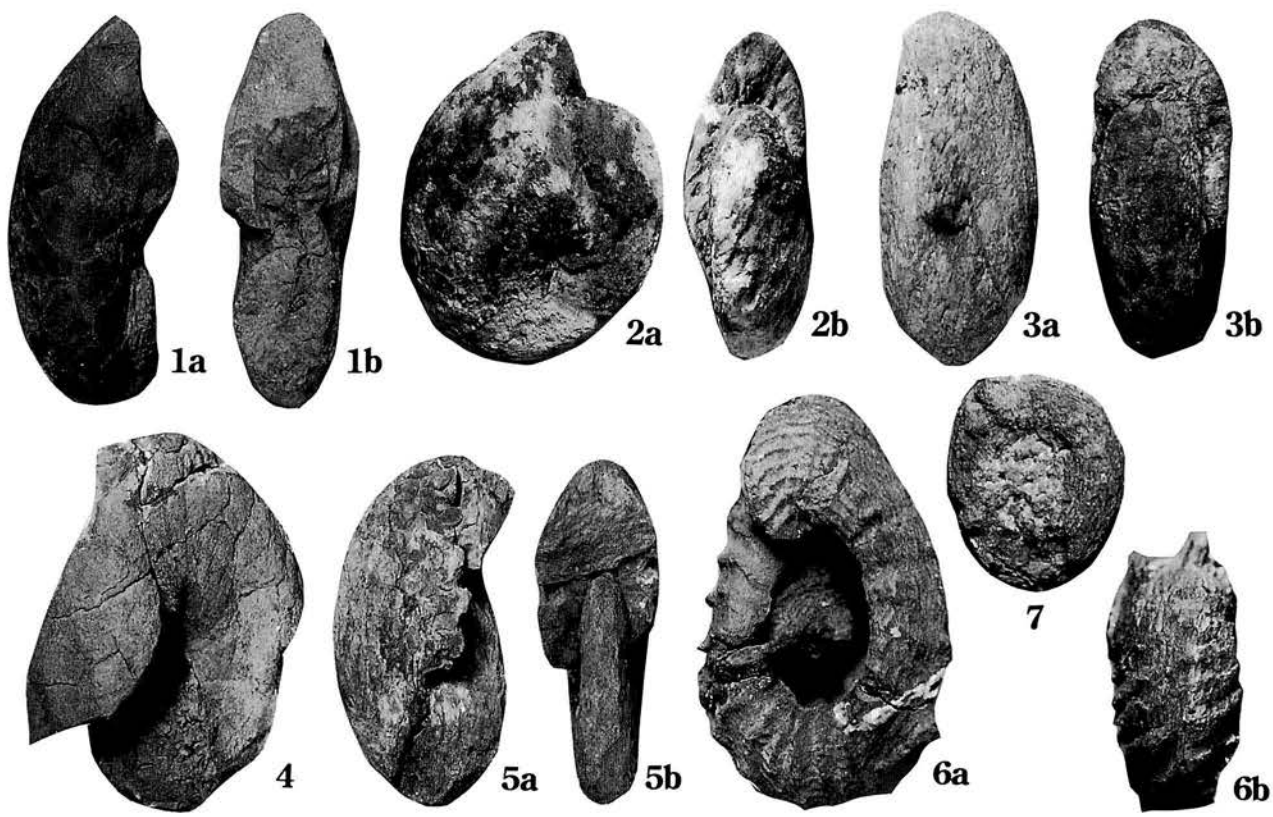


Figure 5. *Jilingites, Stacheoceras* and *Pseudagathiceras* from the Ochiai Formation. All figures approximately natural size unless otherwise stated. **1, 4, 5.** *Jilingites kesennumensis* sp. nov., 1 : IGPS coll. cat. no. 103122, lateral view (a) and cross section (b), 4 : IGPS coll. cat. no. 103119 (Holotype), lateral view, 5 : IGPS coll. cat. no. 103120, lateral (a) and ventral (b) views. **2, 3.** *Stacheoceras* sp., 2 : IGPS coll. cat. no. 103124, lateral (a) and ventral (b) views, 3 : IGPS coll. cat. no. 103123, lateral (a) and ventral (b) views. **6, 7.** *Pseudagathiceras ornatum* sp. nov., 6 : IGPS coll. cat. no. 103135 (Holotype), lateral (a) and ventral (b) views, ×1.6, 7 : IGPS coll. cat. no. 103136, lateral view, ×1.5.

numa City, where it was collected.

Superfamily Cyclolobaceae Zittel, 1895
Family Vidrioceratidae Plummer and Scott, 1937
Genus ***Stacheoceras*** Gemmellaro, 1887

Type species.—*Stacheoceras mediterraneum* Gemmellaro, 1887

Stacheoceras sp.

Figures 4-c; 5-2, 3

Materials.—IGPS coll. cat. nos. 103123 and 103124, from Loc. B-2 collected by H. Araki.

Description.—The conch is involute, subglobular to sublenticular in outline, with a closed umbilicus. One specimen (no. 103124) is tectonically flattened laterally. The phragmocone attains a diameter of 42 mm. The sides are convex and the venter is broadly rounded with rounded ventral shoulders. The shell surface may be smooth. The suture consists of a large bifid ventral lobe and many lateral lobes. The first lateral lobe is primarily bifid and each of its prongs is also bifid. The other lateral lobes are trifid.

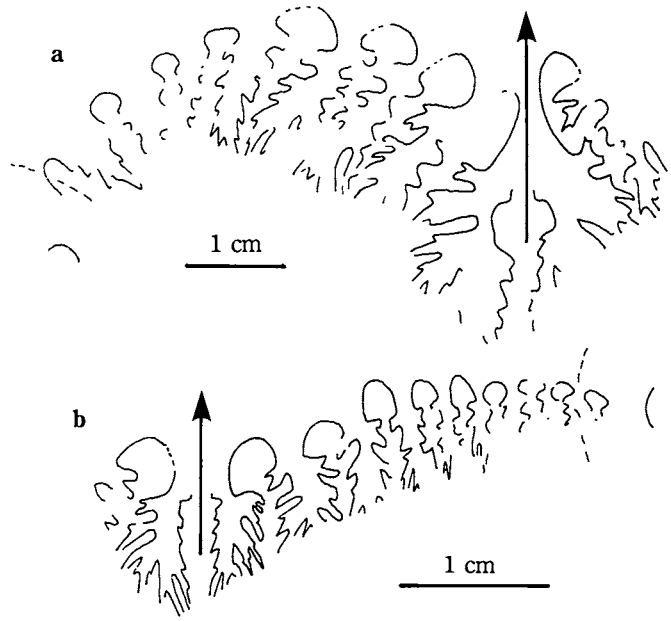


Figure 6. Suture lines of *Timorites takaizumii* sp. nov. from the Ochiai Formation. **a.** IGPS coll. cat. no. 103125 (Holotype), **b.** IGPS coll. cat. no. 103132.

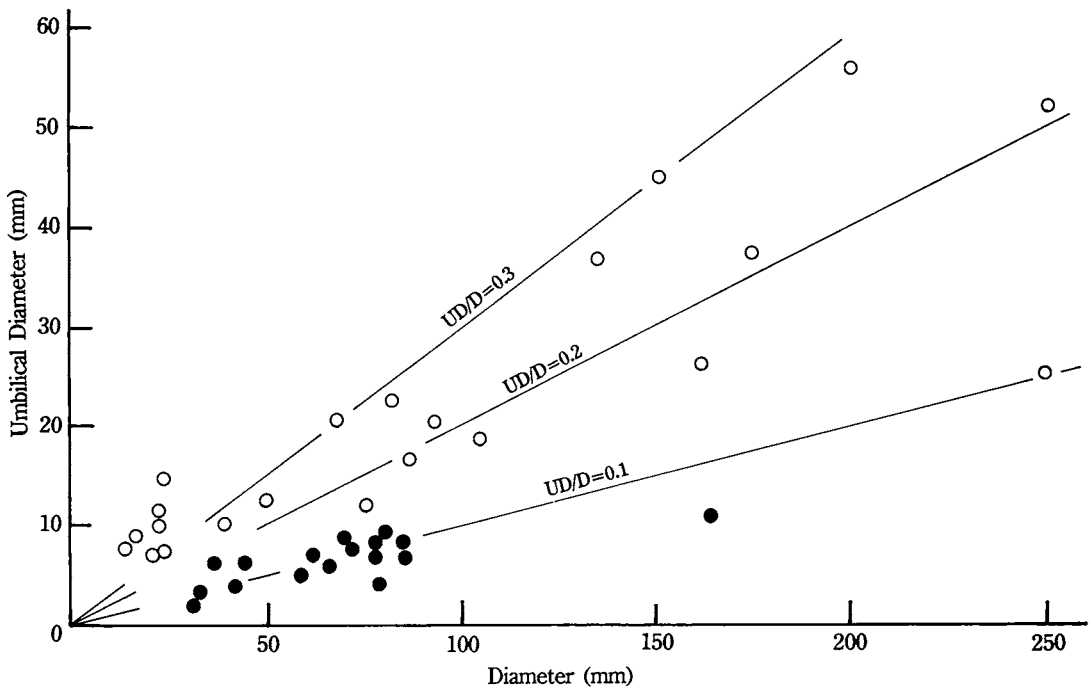


Figure 7. Umbilical diameter/shell diameter ratios of Timorites. Filled circles are *Timorites takaizumii* sp. nov. Open circles other known species of *Timorites*: *T. curvicostatus* Haniel (Haniel, 1915), *T. gemmellaroi* (Haniel) (Haniel, 1915), *T. giganteus* Sheng (Sheng, 1988), *T. intermedium* (Wanner) (Wanner, 1932; Ehiro *et al.*, 1986), *T. markevichi* Zakharov (Zakharov in Kotlyar *et al.*, 1989), *T. schucherti* Miller and Furnish (Miller and Furnish, 1940), *T. sigillarius* Ruzhentsev (Ruzhentsev, 1976), *T. sinensis* Sheng (Sheng, 1984), *T. striatus* Haniel (Haniel, 1915), *T. yunnanensis* Liang (Liang, 1983), *T. uddeni* Miller and Furnish (Miller and Furnish, 1940).

Family Cyclolobidae Zittel, 1895
Genus ***Timorites*** Haniel, 1915

Type species.—*Timorites curvicostatus* Haniel, 1915

Timorites takaizumii sp. nov.

Figures 6-a, b; 8-1—5

Materials.—Holotype: IGPS coll. cat. no. 103125, collected from Loc. B-1 by M. Ehiro. Paratypes: IGPS coll. cat. no. 103126-103132, collected by M. Ehiro, IGPS coll. cat. nos. 103133 and 103134, collected by Y. Takaizumi, all from Loc. B-1.

Diagnosis.—*Timorites* with an almost smooth shell surface and a very small umbilicus.

Description.—The holotype is fairly large, estimated to be more than 250 mm in diameter. Paratypes are moderately large, usually measuring 70 to 85 mm in diameter. The conch is involute and subglobular in outline. It is compressed laterally, but the ratios of width to height of conch vary from 0.3 to 1.0 due to tectonic deformation. Because the outer whorl embraces completely inner whorls in the adult stage, the ratios of umbilical diameter to shell diameter become smaller with increasing height. They are nearly equal or less than 0.1 in mature specimens as shown in Figure 7. The umbilical wall is almost perpendicular and the umbilical shoulder is acutely rounded. The convex sides grade round into a rounded venter. The shell surface is ornamented with fine, weakly sigmoidal growth lines in a few specimens, but smooth in many specimens. The living chamber is about a volution in length.

The sutures are not so well preserved, but are characteristic of *Timorites* as shown in Figure 6.

Comparison.—The Kurosawa species of *Timorites* is easily distinguished from the other species by having a very small umbilicus and nearly smooth shell surface, except for slight growth lines. The umbilical diameter of the present species is about 10 percent of the shell diameter or smaller, while those of the others are larger than 15 percent at a diameter smaller than 200 mm (Figure 7).

Etymology.—The specific name is given in honor of Mr. Yukihiro Takaizumi, who collected many cephalopod fossils from Kurosawa.

Superfamily Adrianitaceae Schindewolf, 1931
Family Adrianitidae Schindewolf, 1931
Genus ***Pseudagathiceras*** Schindewolf, 1931

Type species.—*Agathiceras* (*Doryceras* ?) *wichmanni* Haniel, 1915

Remarks.—*Pseudagathiceras* was established by Schindewolf (1931) based on *Agathiceras* (*Doryceras* ?) *wichmanni* Haniel described from the Basleo beds of Timor and was regarded as valid by Miller (1944) and Ruzhentsev (1962). On the other hand, Miller *et al.* (1957) considered that *Pseudagathiceras* is congeneric with *Doryceras* established by Gemmellaro (1887). The present authors agree with Miller (1944) and Ruzhentsev (1962), and treat *Pseudagathiceras* as a distinct genus, because the species referable to the genus *Pseudagathiceras* have a considerably larger umbilicus and one or two more external lobes than do the species of *Doryceras.* The Coahuila species *P. difuntense* Miller and *P. spinosum* Miller have two rows of prominent spines on the ventrolateral shoulder at full maturity.

Pseudagathiceras ornatum sp. nov.

Figures 4-d; 5-6, 7

Materials.—Two specimens, both from Loc. B-1: IGPS coll. cat. no. 103135 (holotype), collected by Y. Takaizumi, and IGPS coll. cat. no. 103136, collected by M. Ehiro.

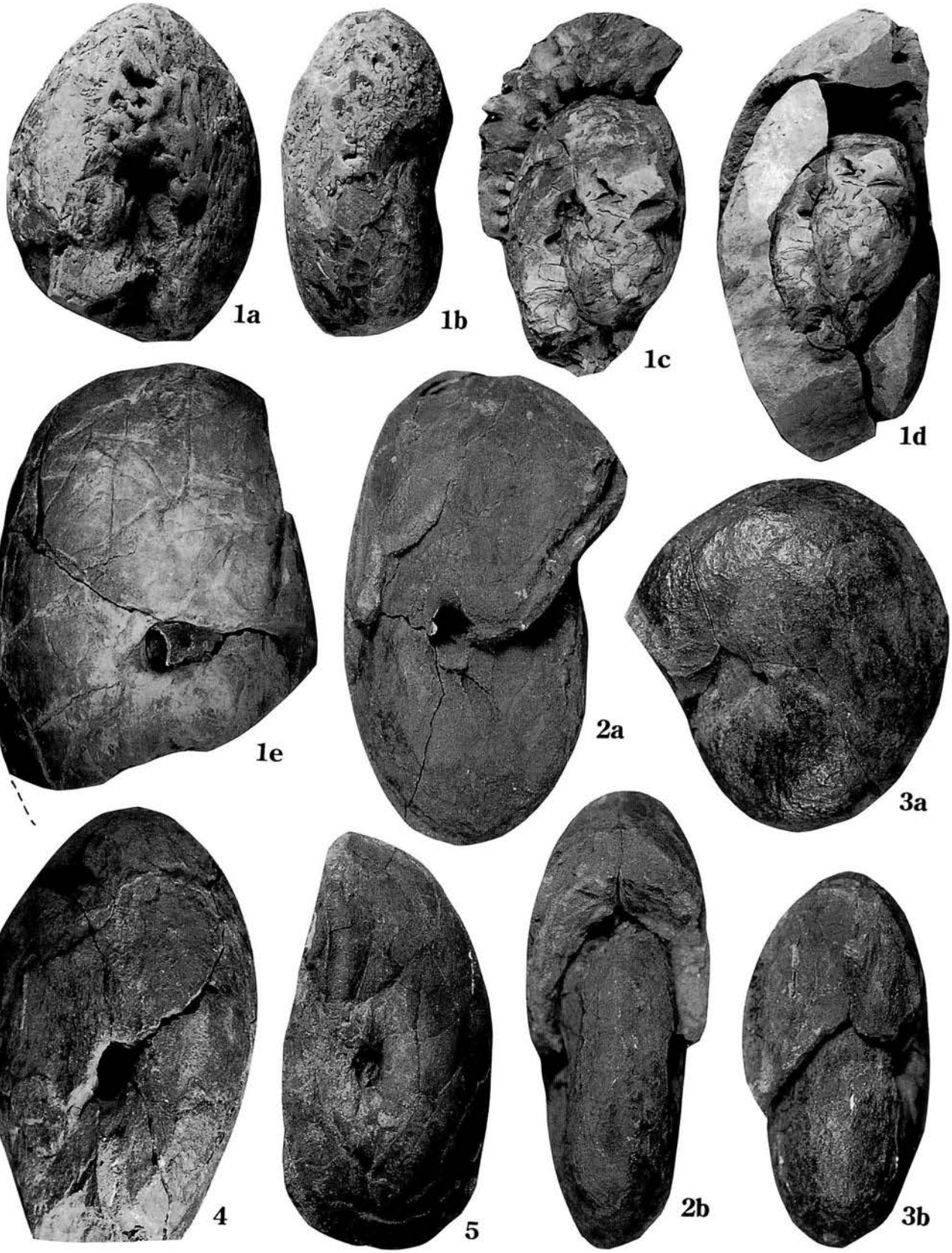
Diagnosis.—A large *Pseudagathiceras* with prominent lateral ribs, ventral spines and a wide umbilicus.

Description.—The conch is subdiscoidal, moderately evolute and widely umbilicate. Holotype is moderately large in size, attaining a diameter of 35 mm in the deformed state, and at the adoral end its umbilical diameter is 15 mm. The venter is broadly rounded and the sides, which converge toward the venter, are also rounded. The whorl is depressed in outline. The surface of the conch is marked by rather prominent longitudinal lirae, and at maturity it is ornamented by radial ribs and two rows of ventrolateral nodes or spines, but the nodes or spines are not so visible on the apertural half of the last whorl. The small paratype has longitudinal lirae and transverse constrictions. The suture is poorly preserved on the paratype, consisting there of some rounded lateral saddles and pointed lateral lobes.

Comparison.—In having prominent lateral ribs and two rows of ventrolateral spines, the present species resembles the Coahuila species, *Pseudagathiceras difuntense* Miller (Miller, 1944, p. 101, plate 29, figs. 6-12) and *P. spinosum* Miller (Miller, 1944, p. 103, plate 29, figs. 1-5). The former is, however, considerably larger than the latter two. It is also distinguished in having more prominent lateral ribs and a larger umbilicus.

Etymology.—The specific name is derived from its remarkable shell ornamentation.

Figure 8. *Timorites takaizumii* sp. nov. from the Ochiai Formation. **1.** Holotype, IGPS coll. cat. no. 103125, lateral (a) and ventral (b) views of phragmocone, ×0.68, ventral view (c) of phragmocone, ×0.47, cross section (d) of living chamber, ×0.42, and lateral view (e) of living chamber, ×0.33. **2.** IGPS coll. cat. no. 103126, lateral (a) and ventral (b) views, ×0.9. **3.** IGPS coll. cat. no. 103133, lateral (a) and ventral (b) views, ×0.78. **4.** IGPS coll. cat. no. 103132, lateral view, ×0.9. **5.** IGPS coll. cat. no. 103130, lateral view, ×1.1.


1a
1b
1c
1d
1e
2a
3a
4
5
2b
3b

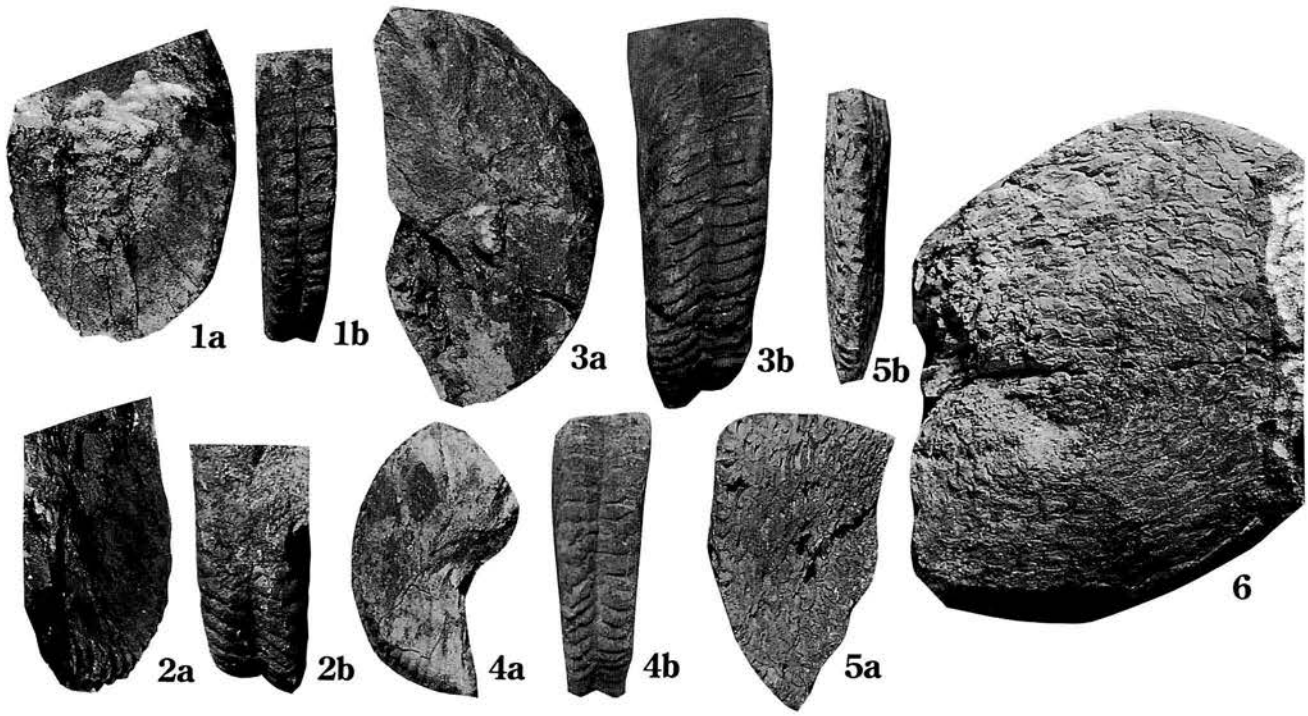


Figure 9. *Propinacoceras* and *Eumedlicottia* from the Ochiai Formation. All figures approximately natural size. **1-4.** *Propinacoceras* sp., 1: IGPS coll. cat. no. 103141, lateral (a) and ventral (b) views, 2: IGPS coll. cat. no. 103138, lateral (a) and ventral (b) views, 3: IGPS coll. cat. no. 103137, lateral (a) and ventral (b) views, 4: IGPS coll. cat. no. 103139, lateral (a) and ventral (b) views. **5, 6.** *Eumedlicottia primas* (Waagen), 5: IGPS coll. cat. no. 103142, lateral (a) and ventral (b) views, 6: IGPS coll. cat. no. 103143, lateral view.

Order Prolecanitida Miller and Furnish, 1954
Superfamily Medlicottiaceae Karpinsky, 1889
Family Medlicottidae Karpinsky, 1889
Genus ***Propinacoceras*** Gemmellaro, 1887

Type species.—*Propinacoceras beyrichi* Gemmellaro, 1887

Propinacoceras sp.

Figures 9-1—4

Materials.—IGPS coll. cat. no. 103137-103140, collected from Loc. B-1 by M. Ehiro, and IGPS coll. cat. no. 103141, from Loc. B-2 collected by H. Araki.

Description.—The conch is involute and thinly discoidal in outline, with a very small umbilicus. The sides are flat and almost parallel, but slightly converge toward the umbilicus. The venter is also flat, but bears two rows of prominent nodes or short ribs, which are separated by a median groove. The umbilical and ventral shoulders are acutely rounded. The suture is only poorly preserved in some specimens and its details cannot be observed.

Genus ***Eumedlicottia*** Spath, 1934

Type species.—*Medlicottia bifrons* Gemmellaro, 1887

Eumedlicottia primas (Waagen)

Figures 4-e, f; 9-5, 6

Sageceras primas Waagen, 1879, p. 39, pl. 2, figs. 7a-c
Medlicottia primas Waagen. Noetling, 1904, p. 355, pl. 17, figs. 1-1b, pl. 19, fig. 1.

Materials.—Two specimens, IGPS coll. cat. no. 103142, collected from Loc. A-2 by M. Ehiro, and IGPS coll. cat. no. 103143, from Loc. B-2 by H. Araki.

Descriptive remarks.—The conch is involute and thinly discoidal to sublenticular in outline, with a closed umbilicus. The phragmocone attains a diameter of at least 65 mm. The flanks are slightly convex and converge toward the venter. The venter is narrow and grooved, with keeled ventrolateral shoulders. The shell surface is smooth.

The suture forms a deep and narrow ventral lobe, a high and narrow ventrolateral saddle, and many lateral and auxiliary saddles and lobes. There are many secondary lobes in the ventrolateral saddle. Ten to eleven saddles, which have notches at midheight on each wing, and subdivided lobes are on the flanks.

In having a smooth shell surface and complex sutures, especially many notched saddles, the present specimens are identified with *Eumedlicottia primas* (Waagen).

Acknowledgments

The authors wish to express their deep gratitude to Brian F. Glenister of the University of Iowa for his critical reading of the manuscript. Deep appreciation is also due to Kunihiro Ishizaki of Tohoku University for his identification of fusulinids. Thanks are also extended to Yukihiro Takaizumi for his kind assistance in the field and providing his specimens. This research was partly supported by a Grant-in-Aid for Scientific Research (C: 07640593) from the Ministry of Education, Science and Culture of Japan to M. Ehiro.

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