# Two genera of Popanoceratidae (Permian Ammonoidea) from the South Kitakami Belt, Northeast Japan, with a note on the age of the Takakurayama Formation in the Abukuma Massif

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# Two genera of Popanoceratidae (Permian Ammonoidea) from the South Kitakami Belt, Northeast Japan, with a note on the age of the Takakurayama Formation in the Abukuma Massif

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**Abstract. Two genera of Permian ammonoid Popanoceratidae are described from the South Kitakami Belt, Northeast Japan : *Tauroceras* from the uppermost part of the Hosoo Formation in the Southern Kitakami Massif, and *Popanoceras* and *Tauroceras*, associated with *Jilingites*?, *Waagenoceras* and *Agathiceras*, from the upper part of the Takakurayama Formation in the eastern marginal part of the Abukuma Massif. These ammonoid specimens are considered in situ occurrences and strongly suggest that these fossil horizons are both Wordian in age.**

## Introduction

Popanoceratidae is rather rare in the Permian strata of the Japanese Islands, although it is a common ammonoid family in Permian deposits of the Urals, Tethys Province and southwestern United States. Only two specimens have previously been described from the South Kitakami Belt of Northeast Japan : *Popanoceras* sp. (Hayasaka, 1965) from the Takakurayama Formation (Takakurayama Group) in the eastern marginal part of the Abukuma Massif and *Tauroceras*? sp. (Ehiro and Misaki, 2005) from the Hosoo Formation in the Kesennuma area of the Southern Kitakami Massif. In addition to these specimens Hayasaka and Nishikawa (1962) once reported the occurrence of *Popanoceras bowmani* (Böse) from unnamed strata in Miharanoro, Hiroshima Prefecture in Southwest Japan. This species has, however, not been described.

Genera belonging to Popanoceratidae are fundamental to the biostratigraphy of Lower to Middle Permian strata (Glenister and Furnish, 1988). Among them, *Tauroceras* is also important with respect to biogeography because it is mainly known from Tethys Province and the southwestern United States. Recently one specimen of *Popanoceras* sp. (from the Takakurayama Formation) and two of *Tauroceras* sp. (from the Takakurayama and Hosoo Formations) were recovered from the South Kitakami Belt (Fig. 1). This paper describes these of Popanoceratidae and some associated ammonoids, and discusses their stratigraphic and biogeographic significance, especially with respect to the age of the Takakurayama Formation in the Abukuma Massif.

## Brief note on the ammonoid-bearing formations and their ammonoid faunas

### The Hosoo Formation

The Hosoo Formation is in the Kesennuma area of the Southern Kitakami Massif (Fig. 2). The Permian strata of the area are divided into the Nakadaira, Hosoo, Kamiyasse, Kurosawa and Nabekoshiyama Formations from the lower to upper positions (Misaki and Ehiro, 2004). The stratigraphic relationships of these formations are all conformable. The Nakadaira Formation, Sakmarian to Artinskian in age, consists predominantly of limestone intercalated with conglomerate, sandstone and mudstone. The thickness exceeds 300 m. The Hosoo Formation, 400–500 m thick, is primarily a mudstone unit with some lenticular sandstone and conglomerate beds. The Kamiyasse Formation ranges in thickness from 200 to 300 m and is dominated by calcareous sandstone, calcareous mudstone and impure limestone. This formation yields many fusulinoideans, corals, brachiopods, mollusks and other fossils, and can be correlated with the Wordian to Capitanian interval. The Kurosawa Formation, Capitanian to Wuchiapingian in age, is composed mainly of mudstone and its total thickness exceeds 1,000 m. The Nabekoshiyama Formation, more than 500 m thick, is composed of a sandstone-dominated lower part and mudstone-dominated upper part. Limestone intercalated in the lower part yields Changhsingian fusulinoideans and smaller foraminifers.

The Hosoo Formation has long been considered to be almost barren of fossils, but Ehiro and Misaki (2005) reported several ammonoid fossils from the middle and upper parts of the formation. The middle part yields *Demarezites* sp., *Demarezites*? sp., *Agathiceras*? sp. and *Adrianites* sp. Ammonoids from the upper part are known from two localities. *Waagenoceras* sp., *Cardiella* sp., *Agathiceras* sp., and *Paraceltites elegans* Girty were collected on the eastern ridge of the Ookadozawa valley, a tributary of the Hosoo River in Kamiyasse district. The other locality (locality H-5 of Ehiro and Misaki, 2005) is a road-cut along a forest road in the southern basin of the Shigejizawa River in the same district and yields *Parastacheoceras bidentatus* Ehiro and Misaki, *Tauroceras*? sp. and *Agathiceras* sp. The present specimen of *Tauroceras* sp. was collected from the latter locality (loc.

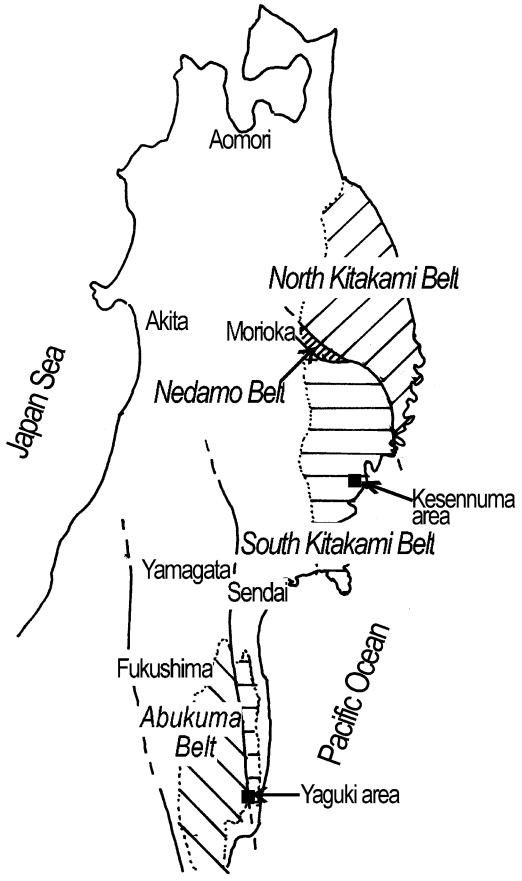


**Figure 1.** Map showing the study areas with the pre-Tertiary tectonic division of Northeast Japan.

H-5 in Fig. 2).

**The Takakurayama Formation**

The Takakurayama Formation is in east of Mt. Takakurayama in the Yaguki area, the southeastern margin of the Abukuma Massif (Fig. 3). It was first proposed as the Takakurayama Series (Iwao and Matsui, 1961). Yanagisawa and Nemoto (1961) called it the Takakurayama Group and subdivided it into the Iriishikura, Motomura and Kashiwadaira Formations, in ascending order. However, Onuki (1966) treated the group as a formation rank and the formations as members. The Iriishikura Member is more than 100 m thick and consists mainly of laminated mudstone. The Motomura Member is 60-7 m, thinning to the south, and is composed of sandstone, conglomeratic sandstone with limestone pebbles, and mudstone. The Kashiwadaira Member, more than 200 m thick, consists of laminated mudstone occasionally associated with thin sandstones and lenticular pebbly mudstones. The strata trend is north-northeast and moderately to steeply dip west. Cross beddings and graded beddings, commonly observed in sandstone beds and laminas, show that no overturned part exists.

*Popanoceras* sp. and *Tauroceras* sp. described in this paper were collected from the upper part of the Kashiwadaira Member in the G2 River (loc. $T_7$ of Yanagisawa, 1967) in association with some ammonoids, such as *Jilingites*? sp., *Waagenoceras* sp., *Agathiceras* sp. (many specimens), and some unidentifiable specimens. Many ammonoid species from this locality have previously been reported by Hayasaka (1965), Yanagisawa (1967), and Tazawa et al. (2005). They are as follows:

Hayasaka (1965):
- *Agathiceras* cf. *suessi* Gemmellaro
- *Popanoceras* sp.
- *Stacheoceras* aff. *grunwaldti* Gemmellaro
- *Waagenoceras* cf. *dieneri richardsoni* Miller and Furnish
- *Pseudogastrioceras*? sp.
- *Propinacoceras* sp.
- Medlicottidae? gen. et sp. indet.
- *Paraceltites* aff. *elegans* Girty

Yanagisawa (1967):
- *Agathiceras* cf. *suessi* Gemmellaro
- *Waagenoceras* cf. *dieneri* Miller and Furnish
- *Propinacoceras* aff. *knighti* Miller and Furnish
- *Medlicottia* cf. *costellifera* Miller and Furnish
- *Paraceltites elegans* Girty
- *P.* aff. *elegans* Girty
- *Paraceltites* sp.
- *Cibolites* cf. *uddeni* Plummer and Scott.

Tazawa et al. (2005):
- *Agathiceras* sp.
- *Roadoceras* sp.
- *Mexicoceras*? sp. (=*Waagenoceras* cf. *dieneri* of Yanagisawa (1967))
- *Propinacoceras* sp.

Of these ammonoids, *Waagenoceras dieneri richardsoni* Miller and Furnish was treated as *Newellites richardsoni* (Miller and Furnish) by Davis et al. (1969). Hayasaka (1965) described two specimens of *Pseudogastrioceras*? sp. and noted that one of them might be *P. zittelli* Gemmellaro. Species previously considered members of *Pseudogastrioceras* Spath, 1930 are placed in three genera: *Altudoceras* Ruzhentsev, 1940, *Pseudogastrioceras* Spath, and *Roadoceras* Zhou, 1985. *Pseudogastrioceras zittelli* is treated as a species of *Altudoceras* (Zhou, 1987). Hayasaka's (1965) two specimens of *Pseudogastrioceras*? sp., however, are fragmental or very poorly preserved, and are difficult to identify on the generic level.

*Cibolites* sp. described by Yanagisawa (1967), reexamined by the present author, is not an ammonoid but probably a gastropod because it has a spiral shell.

In addition to those described, three ammonoid specimens collected by C. Suzuki from the same locality are known. Koizumi (1975, p 73, pl. 16, fig. 2) identified one as *Timorites*? sp. This specimen, having a diameter of about 45 mm, has a small umbilicus (UD/D is about 0.24). Prominent sinuous fine ribs are present on the flanks, and radially elongated pits occur in the central part of the lateral side. From these characters, this specimen probably belongs to *Tauroceras*, although a specific identification is difficult. The rest were identified as *Pseudotirolites*? sp. and *Pseudogastrioceras zittelli* (Tokai Fossil Society, 1995, p. 50). The former is an

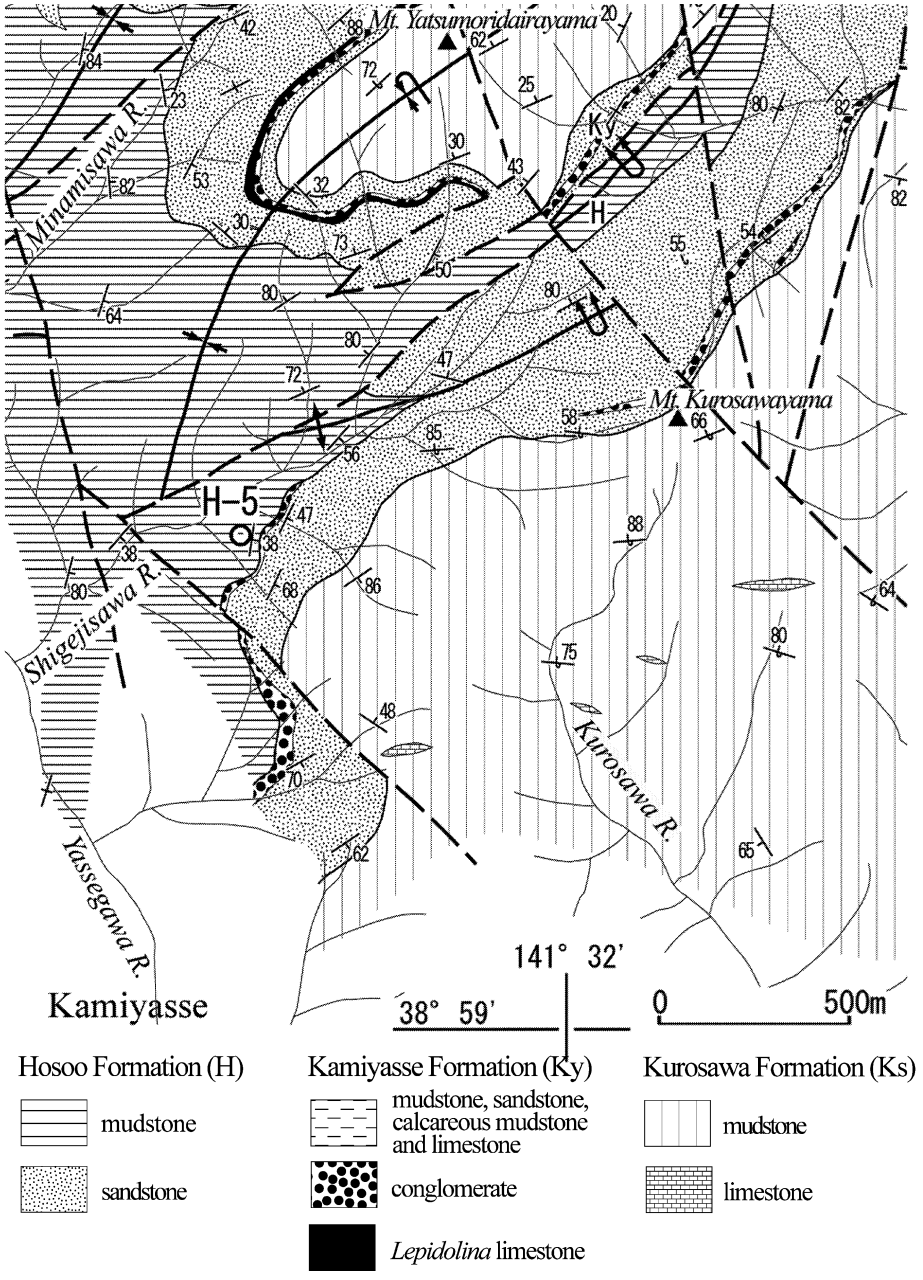


**Figure 2.** Geologic map around the Shigejisawa River, north of Kesennuma (from Ehiro and Misaki, 2005). H-5 is the ammonoid locality.

outer mould of evolute conch, the side of which is flattened and has some radially elongated pits at the midpoint, and is also *Tauroceras*. The shell of the latter specimen is small (D=35 mm) with a small umbilicus (UD/D=about 0.25). Fine longitudinal ribs are present on the broadly rounded sides and venter, and fine, short radial ribs occur on the umbilical edge. From these characters this specimen is considered to be a species of *Roadoceras*, but specific identification is impossible.

Therefore, the Kashiwadaira ammonoid fauna consists of the following 12 genera: *Agathiceras, Popanoceras, Tauroceras, Stacheoceras, Mexicoceras*?, *Waagenoceras, Newellites, Altudoceras, Roadoceras, Propinacoceras, Medlicottia,* and *Paraceltites.*

### Age of the fauna and ammonoid-bearing formations

*Popanoceras* Hyatt, 1884 ranges from the Artinskian to Roadian (Leonova, 2002) and is abundant in the Artinskian to Kungurian of the Southern Urals, Timor, Tumara River

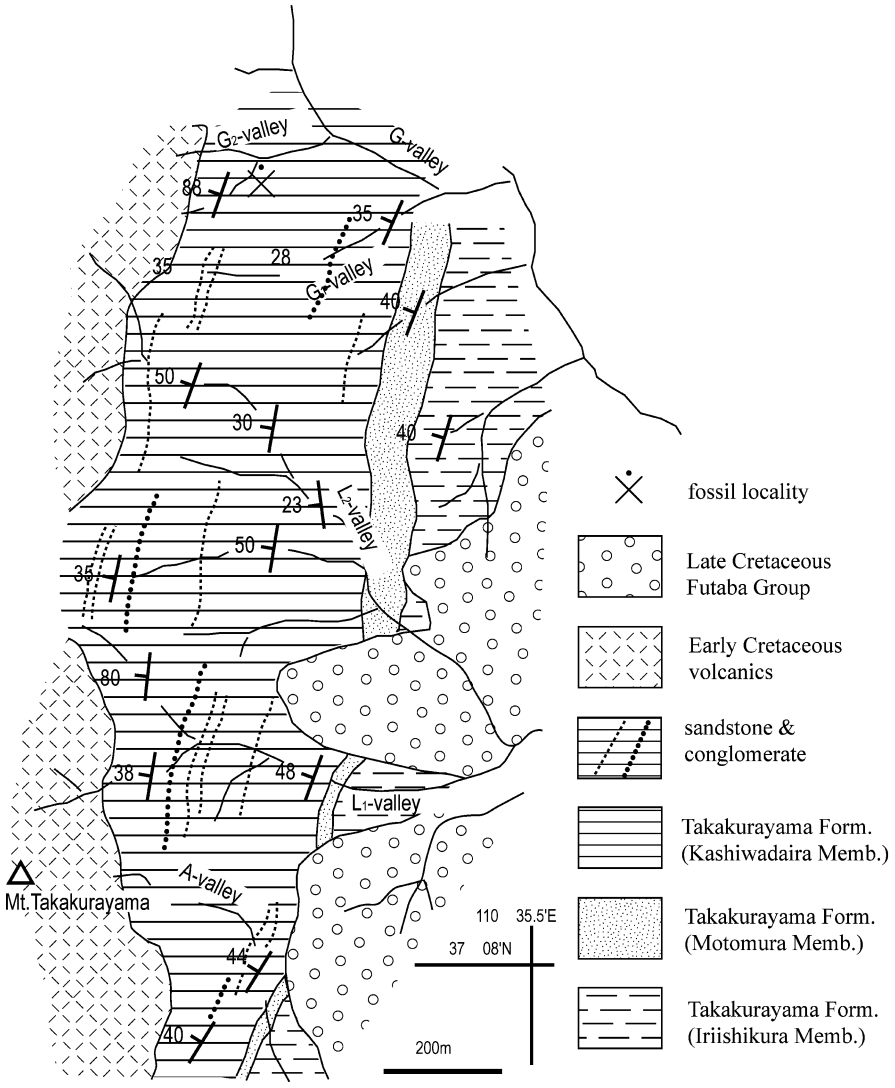


**Figure 3.** Geologic map of the Yaguki area. Valley names are from Yanagisawa (1967).

basin, west and central Texas, and common in the Roadian strata in western Australia, and the Canadian arctic (Glenister and Furnish, 1988). *Tauroceras* Toumanskaya, 1938 ranges from the Roadian to Wordian (Leonova, 2002) but dominates in the Wordian. It is widely known from Tethys Province, including Sicily, Tunisia, Cremea, Pamir, Oman, Iraq, Afghanistan, Malaysia, Timor, Xizang and Zejiang (Kullmann et al., 2000). It has also been reported from Texas and Jiling in Inner Mongolia.

Ehiro and Misaki (2005), based on the ammonoid fauna, correlated the middle and upper parts of the Hosoo Formation with the Roadian and Wordian, respectively. The present Tauroceras sp. specimen from the upper part supports this correlation.

Hayasaka (1965) correlated the Takakurayama Formation with the Socio Stage (Roadian? — Wordian). Yanagisawa considered the Motomura Member to be Early Permian in age based on such Early Permian fusulinoideans as *Pseudofusulina* cf. *ambigua, P.* cf. *fusiformis*, and *Chalaroschwagerina* cf. *vulgaris* from limestone pebbles in the member. These fusulinoideans are, however, derived fossils, because some limestone pebbles yield Middle Permian fusulinoideans (Ueno, 1992). Ueno (1992) correlated the Motomura Member with the late Murgabian on the grounds of the occurrence of *Colania* sp. Tazawa et al. (2005) considered the ammonoid fauna from the Kashiwadaira Member to be Wordian in age, but identified these ammonoids as derived and concluded that the age of the Kashiwadaira Member is Late Permian, because the Capitanian fusulinoidean genus *Lepidolina* was reported from the basal part of the member (Murata, 1964).

The ammonoid fauna of the Kashiwadaira Formation is rich in *Agathiceras*, which ranges from the Moscovian (Carboniferous) to Wordian. *Stacheoceras* is known from Artinskian to Changhsingian strata. *Waagenoceras* is an index fossil of the Wordian, although it ranges up to the Capitanian.

The monospecific genus *Newellites* is Wordian in age. *Altudoceras* ranges from Roadian to Capitanian and *Roadoceras* from Wordian to Wuchiapingian. *Propinacoceras* is an Artinskian — Wordian and *Medlicottia* is a Sakmarian — Wordian genus. *Paraceltites* predominates in Roadian — Wordian strata, although a few specimens are known from the Wuchiapingian. The range of *Mexicoceras* is from Roadian to Wordian.

In addition to these data the occurrence of *Tauroceras* strongly suggests that this ammonoid fauna is Wordian. Only the traditional range of the genus *Popanoceras* (Artinskian to Roadian) conflicts with this age assignment. Therefore, the upper part of the Kashiwadaira Member is most certainly early Wordian of the Middle Permian. This age assignment is consistent with Hayasaka (1965), but differs greatly from Tazawa et al. (2005). Tazawa et al. (2005) also considered the age of the ammonoid fauna from the Kashiwadaira Member to be Wordian, but interpreted these ammonoid fossils and other fossils from the member to be all reworked and the Kashiwadaira Member to be Late Permian in age.

I do not accept Tazawa et al.'s (2005) interpretation that the ammonoid fossils from the Kashiwadaira Member are reworked for the following reasons.

1) Tazawa et al.'s (2005) interpretation is mainly based on the occurrence of Capitanian fusulinoidean fossils such as *Lepidolina multiseptata* Deprat and *Lepidolina* sp. from a horizon about 70 m below the ammonoid horizon (Murata, 1964). In this case, the fusulinoidean age is certainly inconsistent with the age of the ammonoid fauna. These fusulinoideans, however, have neither been described nor figured and need more consideration.

2) Natural casts of the ammonoid fossils (and other fossils such as trilobites and bivalves) consist of black mudstone having exactly the same lithology as the fossil-bearing bed.

3) Most ammonoid specimens are not fragmented and are in a rather good state of preservation, although some of them are tectonically deformed. Trilobite fossils from the same locality are also better preserved compared to other localities such as Kamiyasse and Imo in the South Kitakami Belt.

4) Some pebbly mudstone beds are intercalated in the Kashiwadaira Member, but there are no exotic pebbles occur in the ammonoid-bearing bed.

5) A rather large number of ammonoid specimens, at least 30 specimens having a common stratigraphic range, have been collected from the locality, which is one of the most productive ammonoid localities from the Permian of the South Kitakami Belt. Are these all reworked?

The points in items 2, 3, 4 and 5 strongly indicate that the ammonoid fossils from locality $T_7$ of the Kashiwadaira Member are in situ and the ammonoid-bearing stratum is correlatable with the Wordian.

Ueno (1992) dated the underlying Motomura Member as late Murgabian based on the occurrence of late Murgabian fusulinoideans such as *Minojapanella* (*M.*) *parva* Sheng and *Wutuella* cf. *wutuensis* (Kuo) from the limestone pebbles and *Colania* sp. from the calcareous matrix of the conglomeratic sandstone. The Tethyan standard stage Murgabian is generally correlated with the Wordian Stage. In this case, the ammonoid- and fusulinoidean-based age assignments of the Kashiwadaira Member are approximately consistent, because the Kashiwadaira Member conformably overlies the Motomura Member and the ages of these two members are thought to be about the same. The Kashiwadaira ammonoid fauna, however, includes *Popanoceras*, which was known from pre-Wordian strata previously, and is more likely correlatable with the lower part of the Wordian. This somewhat contradictory age relationship between ammonoid- and fusulinoidean-based strata remains a problem to be resolved.

## Systematic Paleontology

Subclass Ammonoidea Agassiz, 1847
Order Goniatitida Hyatt, 1884
Suborder Goniatitina Hyatt, 1884
Superfamily Marathonitoidea Ruzhentsev, 1938
Family Marathonitidae Ruzhentsev, 1938
Genus *Jilingites* Liang, 1982
Type species : *Jilingites bidentus* Liang, 1982

*Jilingites*? sp.
Figures 4.1, 5.1

*Material.* — IGPS coll. cat. no. 109888

*Remarks.* — A fragmental specimen, obliquely flattened tectonically, is at hand. The conch has broadly rounded sides with a rounded venter and a small or closed umbilicus. The suture partly preserved has at least four sets of rounded saddles and bifid lobes. From these features, especially by suture shape, this specimen probably belongs to the genus *Jilingites*.

*Occurrence and geological age.* — From the upper part of the Kashiwadaira Member of the Takakurayama Formation in the G2 river (loc. $T_7$ of Yanagisawa, 1967), Yaguki, Iwaki City, Fukushima Prefecture. Middle Permian Wordian.

Superfamily Cyclolobioidea von Zittel, 1895
Family Cyclolobidae von Zittel, 1895
Subfamily Cyclolobinae von Zittel, 1895
Genus *Waagenoceras* Gemmellaro, 1887
Type species : *Waagenoceras mojsisovicsi* Gemmellaro, 1887

*Waagenoceras* sp.
Figures 4.2a-c, 5.2

*Material.* — IGPS coll. cat. no. 109889

*Remarks.* — A ventrally flattened specimen is at hand. The original shell form is estimated to be subglobular with a small umbilicus and rounded venter, although it suffered a severe tectonic deformation. The shell surface is smooth. The suture is poorly preserved but typical for advanced cyclolobids and has a wide ventral lobe divided by high denticulate median saddle. High lateral saddles have entirely rounded apices. Deep lateral lobes are strongly

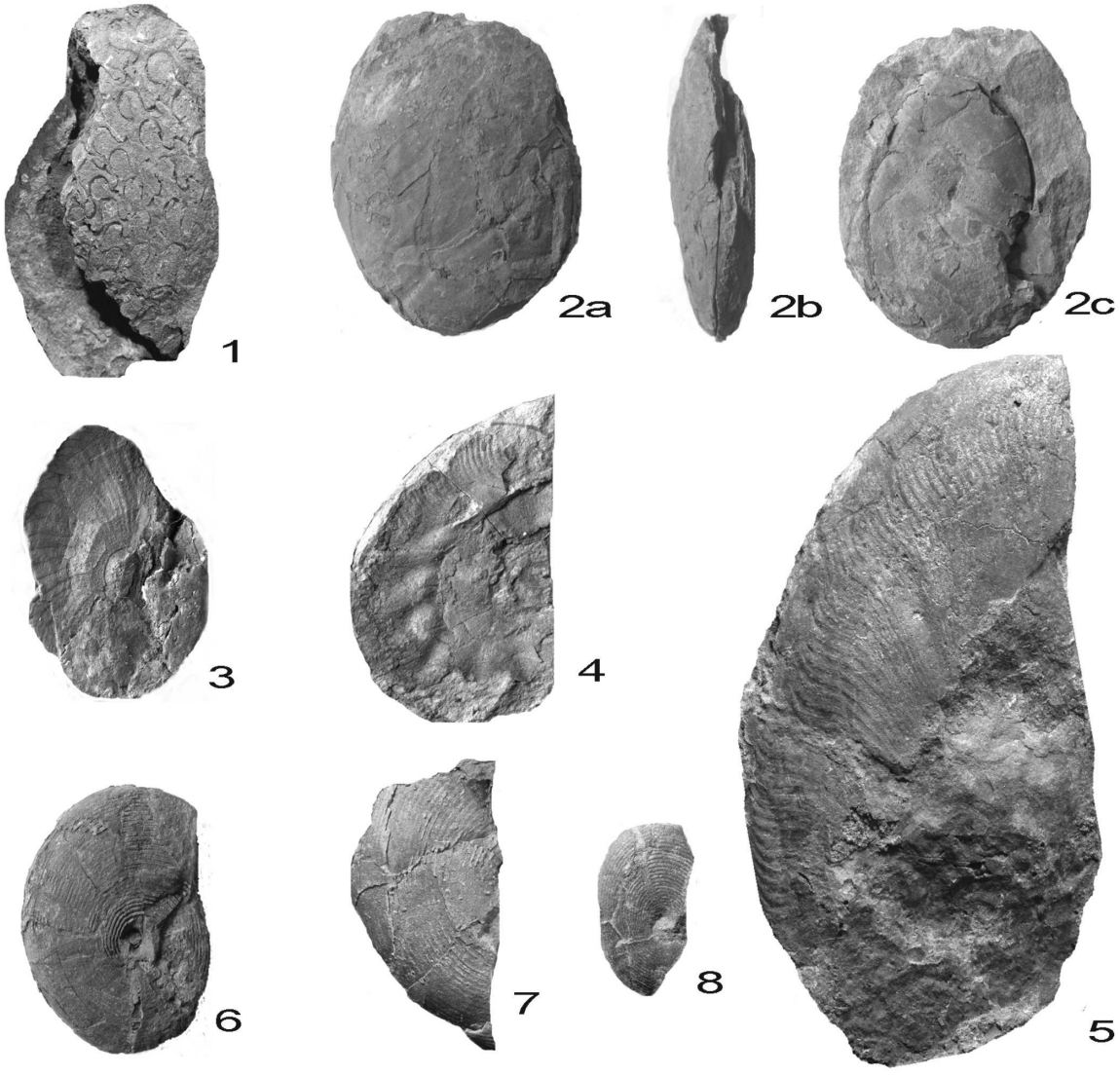


**Figure 4.** Ammonoid fossils from the Kesennuma and Yaguki areas.
1. *Jilingites*? sp., IGPS coll. cat. no. 109888, lateral view, ×1.5; 2a–c. *Waagenoceras* sp., IGPS coll. cat. no. 109889, ×1.0; 3. *Popanoceras* sp., IGPS coll. cat. no. 108990, ×1.5; 4, 5. *Tauroceras* sp., 4. IGPS coll. cat. no. 109891, ×1.5, 5. IGPS coll. cat. no. 108992, ×1.0; 6–8. *Agathiceras* sp., 6. IGPS coll. cat. no. 109893, ×1.5, 7. IGPS coll. cat. no. 109894, ×2.0, 8. IGPS coll. cat. no. 109895, ×2.0.

denticulate. At least five, probably six, lateral lobes are present. Based on these characteristics, the present specimen is considered to belong to the genus *Waagenoceras.*

*Occurrence and geological age.* — From the upper part of the Kashiwadaira Member of the Takakurayama Formation in the G2 river (loc. $T_7$ of Yanagisawa, 1967), Yaguki, Iwaki City, Fukushima Prefecture. Middle Permian Wordian.

Superfamily Popanoceratoidea Hyatt, 1900
Family Popanoceratidae Hyatt, 1900
Genus *Popanoceras* Hyatt, 1884
Type species: *Goniatites sobolewskyanus* de Verneuil in Murchison et al., 1845

*Popanoceras* sp.
Figures 4.3, 5.3

*Material.* — IGPS coll. cat. no. 109890

*Description.* — The shell is thinly discoidal with flat sides and acutely rounded? venter. It is small, having a maximum diameter of about 26 mm and a corresponding umbilical

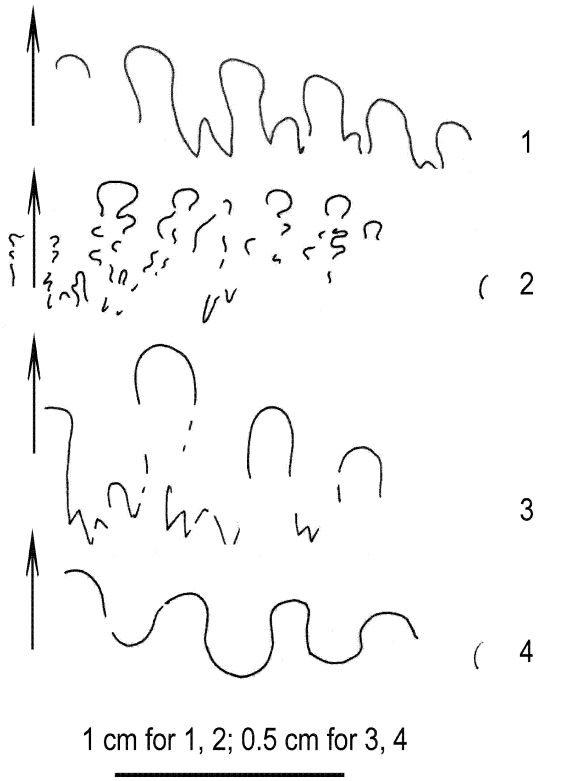


**Figure 5.** Suture lines of *Jilingites?, Waagenoceras, Popanoceras* and *Agathiceras*.
1. *Jilingites*? sp., IGPS coll. cat. no. 109888 ; 2. *Waagenoceras* sp., IGPS coll. cat. no. 109889 ; 3. *Popanoceras* sp., IGPS coll. cat. no. 108990 ; 4. *Agathiceras* sp., IGPS coll. cat. no. 108993

diameter of about 6 mm. Transverse, slightly projected fine ribs, each tracing a rounded ventral sinus, are on the lateral sides. Thirteen or 14 ribs are present per one-fourth of a volution. The suture is partly poorly preserved. The wide ventral lobe is divided by a median saddle into two strongly tridenticulated? branches. The median saddle is about half the height of the ventral lobe. The first lateral lobe is trifid? having nearly the same width as the prongs of the ventral lobe. Second lateral lobe is also trifid. All saddles are rounded.

*Occurrence and geological age.* — From the upper part of the Kashiwadaira Member of the Takakurayama Formation in the G2 river (loc. $T_7$ of Yanagisawa, 1967), Yaguki, Iwaki City, Fukushima Prefecture. Middle Permian Wordian.

Genus Tauroceras Toumanskaya, 1938
Type species : *Popanoceras scrobiculatum* Gemmellaro, 1887

*Tauroceras* sp.
Figures 4.4–5

*Material.* — Two specimens, IGPS coll. cat. nos. 109891 and 109892

*Description.* — Small and rather large specimens are examined. The shell shape of the small specimen (IGPS coll. cat. no. 109891) is discoidal, involute, with a small umbilicus. The maximum diameter is estimated to be about 38 mm, and the corresponding height, width, and umbilical diameter are about 18, 2.5 and 6.5 mm, respectively. The flanks and venter are flattened with abruptly rounded ventrolateral shoulders. Sinuous, fine and dense ribs are prominent on the flat flanks, forming a deep ventral sinus. About 40 ribs occur per one-fourth of a volution. Radially elongated pits are also noteworthy at the midpoint of the lateral side of the inner mould. The suture is not preserved.

The large specimen (IGPS coll. cat. no. 109892) is fragmental, only the outer flank is preserved. It exceeds a diameter of 100 mm. The broad flanks and narrow venter, about 9 mm wide, are nearly flat to broadly rounded with rounded ventrolateral shoulders. Many fine prominent sinuous ribs are on the flanks. The suture is not preserved.

From these characters these specimens are undoubtedly *Tauroceras*, but are difficult to identify at the specific level.

*Occurrence and geological age.* — IGPS coll. cat. no. 109891 from the upper part of the Kashiwadaira Member of the Takakurayama Formation in the G2 river (loc. $T_7$ of Yanagisawa, 1967), Yaguki, Iwaki City, Fukushima Prefecture. — IGPS coll. cat. no. 109892 from the uppermost part of the Hosoo Formation at a road-cut along a forest road (loc. H-5 of Ehiro and Misaki, 2005) in the southern basin of the Shigejizawa River, Kesennuma City, Miyagi Prefecture.

Superfamily Agathiceratoidea Arthaber, 1911
Family Agathiceratidae Arthaber, 1911
Genus *Agathiceras* Gemmellaro, 1887
Type species : *Agathiceras suessi* Gemmellaro, 1887

*Agathiceras* sp.
Figures 4.6–8, 5.4

*Material* — IGPS coll. cat. nos. 109893, 109894, and 109895

*Description.* — Specimens small to moderate size ; diameter 23–30 mm. Conch is involute and due to tectonic deformation, thinly discoidal to spherical in outline, with an almost closed umbilicus. The sides of the shell are flat or slightly convex and umbilical shoulders are rounded. Venter is convex with rounded ventrolateral shoulders. Shell surface is ornamented by many fine spiral lirae. The suture is poorly preserved in one specimen (no. 109893), and four rounded saddles and three almost rounded lobes are present on the lateral side.

*Occurrence and geological age.* — From the lower part of the Kashiwadaira Member of the Takakurayama Formation in the G2 river (loc. $T_7$ of Yanagisawa, 1967), Yaguki, Iwaki City, Fukushima Prefecture. Middle Permian Wordian.

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