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# ***Trematoceras watanabei*, a new orthoconic nautiloid species from the Middle Triassic Fukkoshi Formation, Miyagi Prefecture, Northeast Japan**

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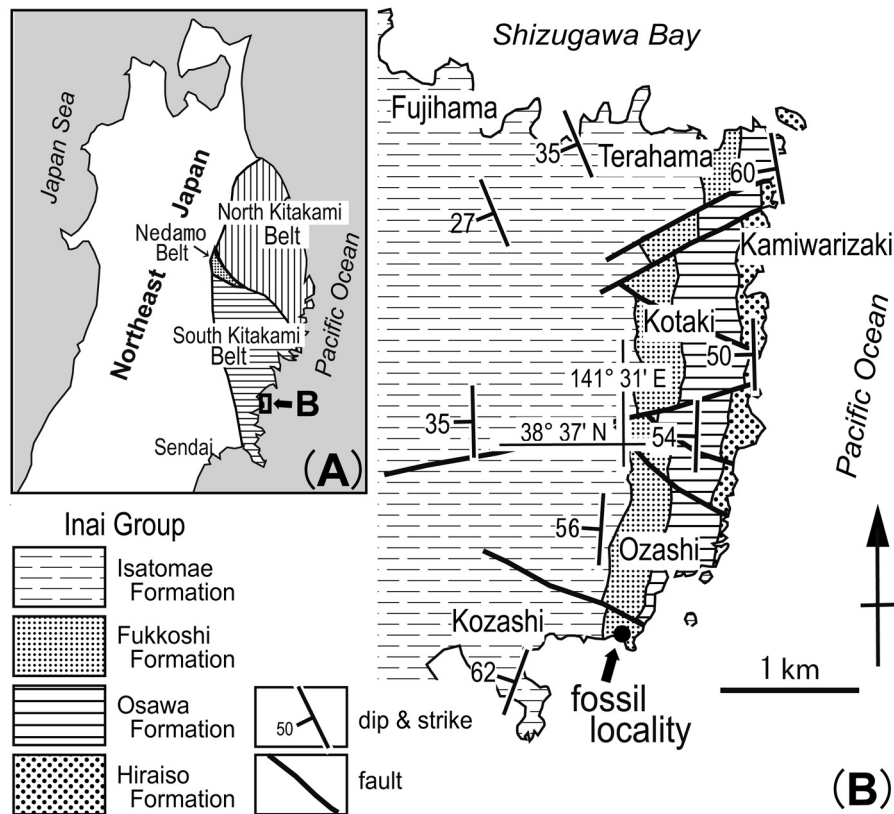
**Abstract:** A new species of an orthoconic nautiloid cephalopod, *Trematoceras watanabei*, is described from laminated sandy mudstones in the Ozashi area, Jusanhama, Ishinomaki City, Miyagi Prefecture, Northeast Japan. Its type stratum is the Anisian (lower Middle Triassic) Fukkoshi Formation of the South Kitakami Belt. Endosiphuncular deposits remaining in two well-preserved specimens of the species support the decision that *Trematoceras* should be removed from the order Orthocerida, and instead be placed in the Pseudorthocerida. The principal character that differentiates *T. watanabei* from a comparable species (i.e., *T. hikichii*) is the development of distinctly longer camerae.

## **Introduction**

Little has been published on the taxonomy of Triassic orthoconic nautiloid cephalopods in Japan. Only Niko et al. (2016) described and named a single species of *Trematoceras* (*T. hikichii*) from Olenekian (upper Lower Triassic) mudstones of the Osawa Formation, Miyagi Prefecture. However, a considerable number of further specimens comparable to their discoveries is found in publications of faunal lists of various Japanese sites. The first report was probably made by Yehara (1927), who documented the occurrence of *Orthoceras* sp. from the Upper Triassic Kochigatani Group, Kochi Prefecture (Kobayashi and Ichikawa, 1951). This is the only representative of a Triassic orthocerid in the Kurosegawa Belt up to now. Besides the abovementioned species, *T. hikichii* Niko, Ehiro and Takaizumi, 2016, whose type stratum is a constituent of the South Kitakami Belt, all further records of Triassic orthoconic nautiloid cephalopods derive from the Maizuru Belt. Reports of these occurrences are listed as follows: Nakazawa et al. (1954; *Orthoceras* sp. from the Anisian (lower Middle Triassic) Miyanoooku Formation, Okayama Prefecture; correspond *Michelinoceras* sp. in Nakazawa, 1958), Nakazawa et al. (1957; *Orthoceras* sp. from the Anisian Waruishi Formation, Kyoto Prefecture; correspond *Michelinoceras* sp. in Nakazawa, 1958), Nakazawa (1958; *Michelinoceras* sp. from the Olenekian Hirobatake and Narawara Formations, Kyoto Prefecture),

Nakazawa and Nogami (1958; *Michelinoceras* sp. from the Olenekian part of the Oro Formation, Kyoto Prefecture), and Ishibashi (2005; *Michelinoceras?* sp. from the Waruishi Formation). The present paper describes *Trematoceras watanabei* sp. nov. as the second species occurrence of an orthoconic nautiloid from the Triassic of the South Kitakami Belt.

The cephalopod specimens described herein were collected from a coastal outcrop (approximately latitude N 38°36' 18", longitude E 141°30' 59") in the Ozashi area, Jusanhama, Ishinomaki City, Miyagi Prefecture, Northeast Japan (Figure 1). According to Kamada and Takizawa (1992) the Triassic rocks in this area are divided into the Hiraiso, Osawa, Fukkoshi and Isatomae Formations in ascending order. The newly described orthoconic nautiloid species derives from the Fukkoshi Formation, that mainly consists of sandstone and alternating beds of sandstone and mudstone. The deposits intercalate with thick laminated sandy mudstone beds, about 30 meters in total thickness, in its middle part. The two cephalopod-bearing beds, i.e., Fk-1a and about 3 meters above Fk-1b, are in the topmost part of the mudstone beds (Figure 2). The Fukkoshi Formation represents the submarine fan complex deposited in a deep-water environment (Kamada, 1984). Onuki and Bando (1959) assigned the formation to the Anisian, based on the presence of age determining ammonoids, such as *Hollandites* sp., *Balatonites* cf. *kitakamicus* (Diener), and *Gymnites* cf. *watanabei* (Mojsisovics).



**Figure 1.** Index map (A) and geologic map (simplified from Kamada and Takizawa, 1992) (B) of the Ozashi area, showing the fossil locality.

*Repository.* All examined specimens are repositied in the Tohoku University Museum (Institution abbreviation: IGPS = Institute of Geology and Paleontology, Faculty of Science, Tohoku University, Sendai).

### Systematic Paleontology

Order Pseudorthocerida Barskov, 1963

Superfamily Pseudorthoceratoidea Flower and Caster, 1935

Family Trematoceratidae Zakharov, 1996

Genus *Trematoceras* Eichwald, 1851

*Type species.*—*Orthocera* [sic] *elegans* Münster, 1841; Carnian (lower Upper Triassic) in Carnic Alps.

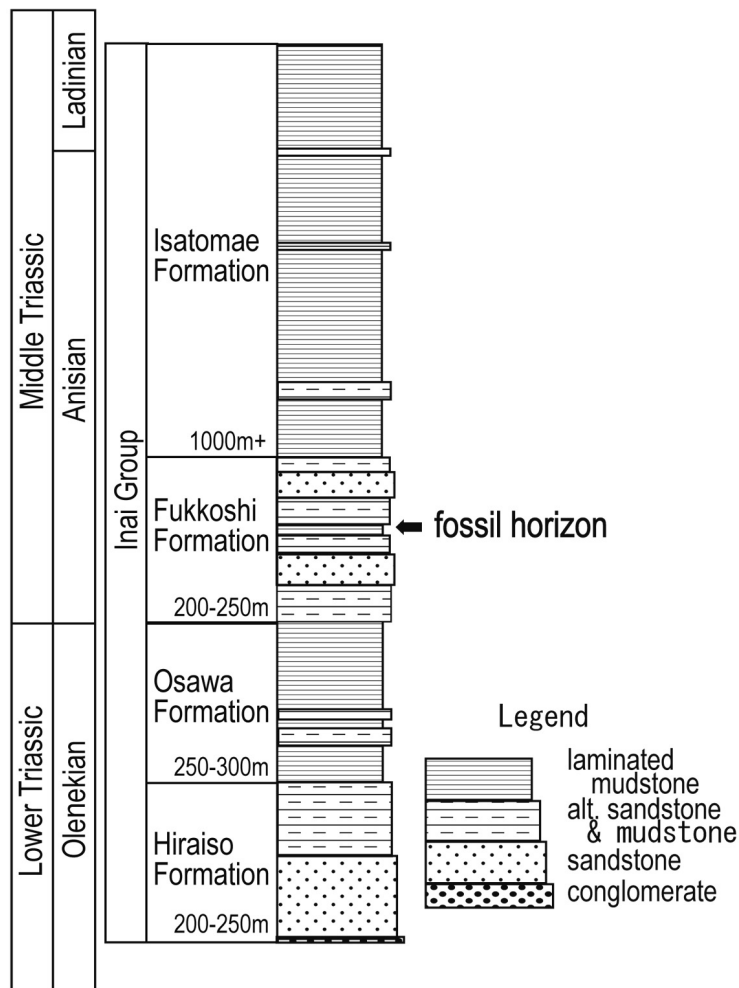
*Discussion.*—Two well-preserved specimens from the Fukkoshi Formation reveal that the new species of *Trematoceras* has endosiphuncular deposits even in the adoral shell. Although Jeletzky and Zapfe (1967) did not describe these in their publication, similar deposits are visible in their figure (pl. 4, fig. 3) of *T. cf. triadicum* Mojsisovics, 1873, collected from the Rhaetian (upper Upper Triassic) Zlambach Marl, Austria. Judging, and based on the

new Japanese finding, the deposits in the Austrian specimen seem organic. There are two opposing views about the higher taxonomic position of the genus: (1) *Trematoceras* belongs into the order Orthocerida (e.g., Sweet, 1964; Shigeta and Nguyen, 2014; Niko et al., 2016), while (2) Schastlivtceva (1986, 1988) and Zakharov (1996) assigned *Trematoceras* to the order Pseudorthocerida. These present knowledges derived from the Japanese and Austrian species support the latter decision advocating a pseudorthocerid affinity of *Trematoceras*.

*Trematoceras watanabei* sp. nov.

Figure 3

*Diagnosis.*—Species of *Trematoceras* with adoral conch expansion of approximately 3° in angle and ornamentation of fine transverse lirae; camerae moderate to long, with 0.4–1.4 in maximum width/length ratio; septal necks suborthochoanitic; connecting rings bear distinct constrictions at siphuncular foramina; cameral deposits episeptal-mural and hyposeptal; endosiphuncular deposits unfused.

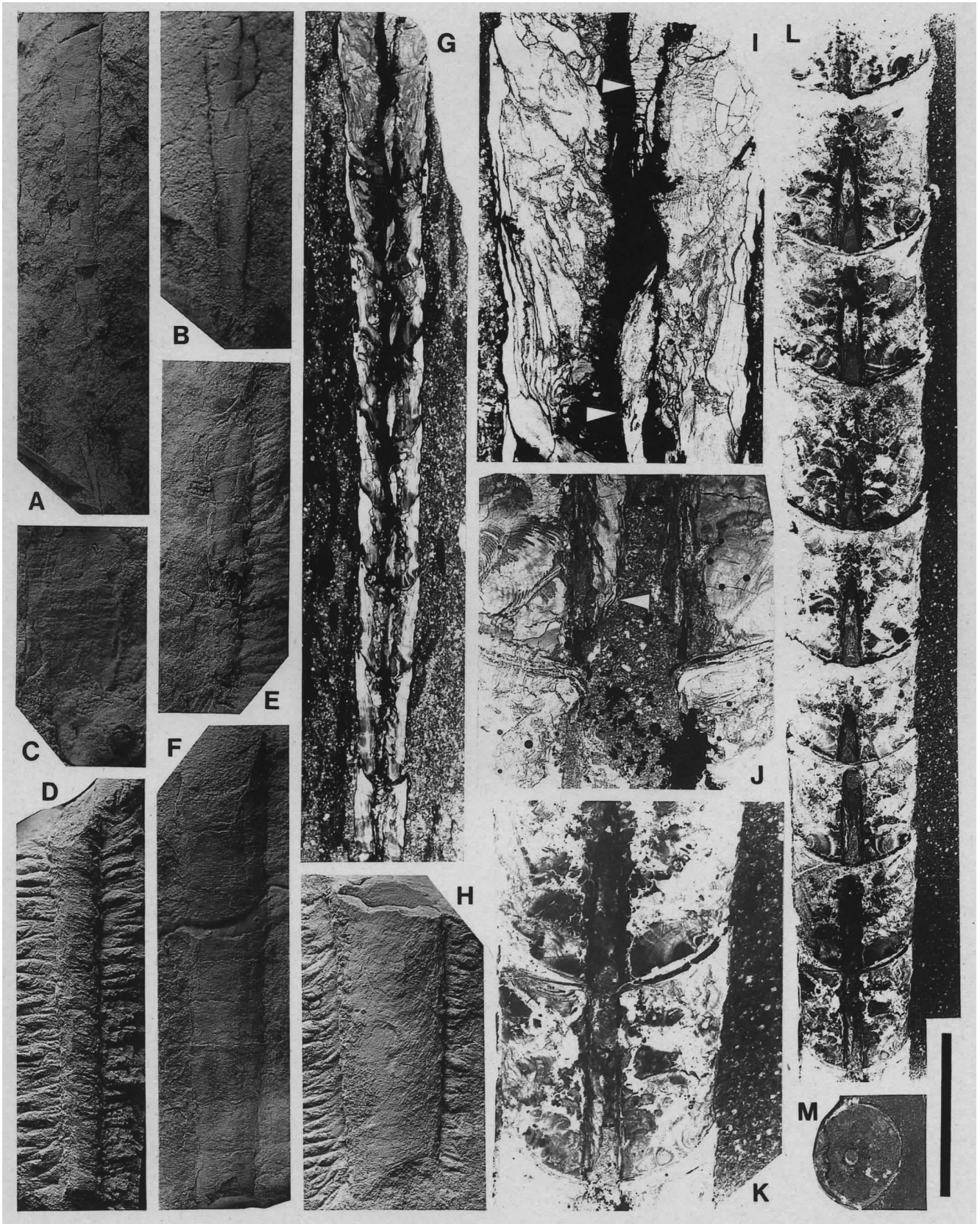


**Figure 2.** Simplified columnar section of the Lower-Middle Triassic Inai Group in the South Kitakami Belt, Northeast Japan, showing the fossil horizon (Fk-1a and Fk-1b). The lowermost part of the Hiraiso Formation is not exposed in the Ozashi area.

*Description.*—Longiconic orthocones with gradual conch expansion; except for apical part of a paratype (IGPS coll. cat. no. 112399), where cross sections of conch are circular, most specimens are more or less deformed and exhibit oval to flattened lenticular cross sections; the holotype is imperfect phragmocone, which is 53 mm in length and approximately 6 mm in reconstructed diameter near its adoral end; body chamber attains approximately 9 mm in reconstructed diameter in a paratype (IGPS coll. cat. no. 112401); reconstructed angles of conch expansion are 4°–6° in apical decreasing to approximately 3° in adoral part of the shell; apex and peristome not preserved. Conch surface ornamented by fine transverse lirae. Sutures directly transverse; septa moderately concave; camerae moderate to long for the genus, having 0.4–1.4 in form ratio (maximum width per length). Siphuncle nearly central in position;

siphuncular wall consists of suborthochoanitic septal necks and slightly thickened connecting rings; length of septal neck is very short (0.33 mm in the holotype); connecting rings cylindrical with distinct constrictions at siphuncular foramina; thickness of connecting rings maximum 0.04 mm in the holotype. Cameral deposits well developed, differentiated into episeptal-mural and hyposeptal; endosiphuncular parietal deposits unfused, developed mainly on ventral siphuncular wall in apical shell of a paratype (IGPS coll. cat. no. 112402) and adoral shell of the holotype; incipient parts of endosiphuncular deposits occur at apical part of connecting ring, then also grow adorally; siphuncular foramina lack deposits.

*Material examined.*—Holotype, IGPS coll. cat. no. 112409. Paratypes, IGPS coll. cat. nos. 112398, 112399, 112401–112403, 112406–112408. In addition, three poorly



preserved specimens, IGPS coll. cat. nos. 112400, 112404, 112405, were also examined.

**Occurrence.**—Fk-1a (IGPS coll. cat. nos. 112398–112405) and Fk-1b (IGPS coll. cat. nos. 112406–112409) in the middle part of the Fukkoshi Formation, the Ozashi area, Jusanhama, Ishinomaki City, Miyagi Prefecture, Northeast Japan.

**Etymology.**—The species name is to honor Mr. Yuta Watanabe, who discovered important specimens including the holotype and two of the paratypes (IGPS coll. cat. nos. 112407, 112408) and making them available for this study.

**Discussion.**—General conch shape and structure of the siphuncular wall of the Fukkoshi specimens are exclusive morphological characters restricted to the genus *Trematoceras*. Among the previously known about 40 species of the genus, *T. watanabei* sp. nov. is similar to the Olenekian species *T. hikichii* Niko, Ehiro and Takaizumi (2016, p. 1–3, fig. 1), from the Osawa Formation (type stratum) that is conformably overlain by the Fukkoshi Formation. The principal difference between these species is their cameral length. Form ratios (maximum width/length) of *T. hikichii* are 1.6–2.3, whereas *T. watanabei* has much longer camerae and ratios of 0.4–1.4. In addition, stronger curvature of septal necks and deeper constrictions of connecting rings of *T. watanabei* compared to those of *T. hikichii* are distinctive. Because endosiphuncular deposits are not preserved in *T. hikichii*, direct comparison of *T. watanabei* and *T. hikichii* is impossible regarding this criterion. However, the pronounced differences of camerae, septal necks, and connecting rings support to separate the taxa on the specific level.

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**Figure 3.** *Trematoceras watanabei* sp. nov. **A–C:** paratype, IGPS coll. cat. no. 112399, imperfect phragmocone; A, side view; B, partial enlargement of A to show details of apical shell; C, partial enlargement of A to show details of surface ornamentation. **D, J–M:** holotype, IGPS coll. cat. no. 112409, imperfect phragmocone; D, lateral view, venter on right; J, partial enlargement of L to show details of endosiphuncular deposits (arrow), septal neck and connecting rings; K, partial enlargement of L to show details of cameral deposits; L longitudinal thin section, slightly oblique for dorsoventral plane, venter on left; M, transverse polished section near adoral end, venter down. **E, G, I:** paratype, IGPS coll. cat. no. 112402, imperfect phragmocone; E, lateral view, venter on right; G, longitudinal thin section, venter on right; I, partial enlargement of G to show details of endosiphuncular deposits (arrows). **F:** paratype, IGPS coll. cat. no. 112403, side view of imperfect phragmocone. **H:** paratype, IGPS coll. cat. no. 112401, side view of imperfect body chamber. Scale bar is 20 mm in A, D, E, F, H; 5 mm in B, C; 3 mm in G, K; 1 mm in I, J; 6 mm in L; 10 mm in M.

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