# Changhsingian (latest Permian) orthoconic cephalopods from the South Kitakami Belt, Northeast Japan

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Abstract: Three Changhsingian (latest Permian) species of orthoconic cephalopods from the South Kitakami Belt, Northeast Japan are described with collections of Tohoku University Museum and Iwate Prefectural Museum. *Cycloceras ofunatoense* sp. nov. was collected from shales of the upper part of the Toyoma Formation at Maeda in Ofunato City, Iwate Prefecture. Previously, this species erroneously assigned to *Protocycloceras* or *Pseudocycloceras*. *Neorthoceras*? sp. and undeterminable phragmocone were collected from shales of the Senmatsu Formation at Senmatsu, Okago, Fujisawa-cho in Ichinoseki City, Iwate Prefecture.

## Introduction

It must be said that our knowledges concerning Late Permian orthoconic cephalopods in Japan are extremely insufficient. The reason is because their occurrences are very rare and limited in the terrigenous faces of the South Kitakami Belt, Northeast Japan, in which all fossils are more or less deformed. The purpose of this paper is to add new findings for the poorly known field on the bases of the material kept in the Tohoku University Museum, Sendai (prefixed IGPS) and Iwate Prefectural Museum, Morioka (prefixed IPMM). Although detailed geographic positions of the specimens are not always clear, we attempt to describe morphologies and determine taxonomic positions for them in light of the importance.

# Systematic paleontology

Subclass Orthoceratoidea Teichert, 1967 Order Orthocerida Kuhn, 1940 Family Cycloceratidae Hyatt, 1883 Genus **Cycloceras** M'Coy, 1844 Type species. Orthoceras laevigatum M'Coy, 1844.

# Cycloceras ofunatoense sp. nov. Figures 1.1–1.6

Protocycloceras cf. cyclophorum (Waagen). Hayasaka, 1924, p. 46–49, pl. 6, figs. 1–3

*Cycloceras*? sp. nov., Shimizu and Obata, 1936, p. 23. *Pseudocycloceras*? sp., Koizumi, 1975, p. 23, pl. 3, figs. 6a–b.

*Diagnosis*. Species of *Cycloceras* with gradually expanded conchs with 3° in reconstructed angle and annulated; annulations on most part of body chamber are continuous, close, and strongly prominent; shell surface lacks ornamentation except for annulations.

Description. The type series consists of three fragmentary, deformed and annulated molds; the holotype is an orthoconic body chamber indicating 92 mm in length and gradual conch expansion; its reconstructed diameters as circular transverse section are 29 mm near adoral end and 27 mm at approximately one third part from the point, whose measurements provide for reconstructed expansion angle of 3°; two paratypes respectively represent more apical and more adoral shells than the holotype; a younger shell (phragmocone?, IGPS coll. cat. no. 112947) preserved as an external mold, has 32 mm in length and may be 10 mm in reconstructed diameter; another paratype (IGPS coll. cat. no. 112949) is a small fragment of body chamber with 43 mm in length; apex and peristome are not preserved. Shape and spacing of annulations exhibit considerable ontogenetic changes; apical annulations are weak, approximately 0.5 mm in height, having nearly flat and relatively wide interspaces, and having bluntly pointed crests; annulations on body chambers shift continuous, close and strongly prominent type, whose crests are bluntly pointed to narrowly rounded and heights range from 1.9 to 2.6 mm; interspaces of adoral annulations are strongly concave; in the most adoral shell of the largest specimen (paratype, IGPS coll. cat. no. 112949), annulations abruptly disappear; except for this gerontic (or pathological?) part, approximate numbers of annulations in corresponding reconstructed conch diameter

are 4–5 in apical and 8–10 in adoral shells. Besides annulations, ornamentation on shell surface is absent. No internal structures including suture, septa, siphuncle, and cameral deposits are preserved.

*Material examined.* Holotype, IGPS coll. cat. no. 112948. Paratypes, IGPS coll. nos. 112947, 112949.

Occurrence and age. The holotype and a paratype (IGPS coll. cat. no. 112947) are preserved on an identical shale block. Another paratype (IGPS coll. cat. no. 112949) occurs in brownish weathered sandy shale associated with a brachiopod, *Lamnimargus*. According to the accompanied labels, their locality is Maeda in Ikawa-cho, Ofunato City, Iwate Prefecture, Northeast Japan. This area is a well-known fossil locality of the upper part of the Toyoma Formation. The Maeda fauna is of Changhsingian (the latest Permian) age as indicated by ammonoid (Ehiro, 1996), bivalves (Nakazawa, 1998), and brachiopods (Tazawa, 2008).

*Etymology.* The specific name is derived from Ofunato. The type locality of the new species belongs to this city.

Discussion. As indicated by the above synonym list the present species was assigned Protocycloceras Hyatt in Zittel 1900, Cycloceras M'Coy, 1844, and Pseudocycloceras Barskov, 1959. We consider that this species should be placed in Cycloceras because (1) its slender conch shape, continuous and transverse annulations in the apical body chamber clearly correspond to the diagnosis of the genus, (2) distinction between Cycloceras and Protocycloceras is difficult only the external conch characters, but occurrences of the latter genus are confined to the Lower Ordovician, and (3) the Silurian genus Pseudocycloceras is characterized by its relatively rapid conch expansion. The external shell morphologies of the species also agree closely with those of Lopingoceras Shimansky in Ruzhentsev et al., 1962, and Neocycloceras Flower and Caster, 1935, whose stratigraphic range reaches the Upper Permian. However, Lopingoceras has distinctly spaced annulations with nearly flat to weakly depressed interspaces even in the body chamber and annulations of Neocycloceras indicate sinuses.

The most similar species to *Cycloceras ofunatoense* sp. nov. is *C. bicinctum* (Abich, 1878, p. 26, 27, pl. 4, figs. 5, 5a; Shimansky *in* Ruzhentsev and Sarycheva, 1965, pl. 16, figs. 14a, b), which occurs in the Dzhulfian (early late Permian) *Araxoceras* ammonoid zone of Azerbaijan. The principal difference between them is the apparently weaker development of annulations in *C. bicinctum*. As suggested by Hayasaka (1924), the new species also similar to *Cycloceras cyclophorum* (Waagen, 1879, p. 68, 69; 1887, pl. 6, figs. 7a, b, 8) from the late Permian part of the *Productus* Limestone in the Salt Rang, Pakistan. When compared at the nearly same growth stages, *Cycloceras cyclophorum* has the slightly wider interspaces between annulations than those of *C. ofunatoense*.

Shimizu and Obata (1936) stated that this Toyoma species should be compare with *Cycloceras laevigatum* (McCoy, 1844, p. 10, pl. 1, fig. 3; Histon, 1998, p. 54, 55, pl. 6, figs. 5a, b) from the Carboniferous of Ireland and *C. obliqueannulatum* (Waagen, 1879, p. 69, 70; 1887, pl. 6, figs. 9, 10) from the late Permian of Pakistan. *Cycloceras laevigatum*, however, is well differentiated from *C. ofunatoense* by the possession of transverse lirae. Furthermore, there is a considerable chronological gap between these two species. Teichert and Kummel (1973) changed the generic assignment of *obliqueannulatum* to *Neocycloceras*. We think this replacement is reasonable because of its sinuated annulations.

Order and Family Uncertain Genus **Neorthoceras** Shimizu and Obata, 1936 *Type species. Orthoceras verbeeki* Haniel, 1915.

# Neorthoceras? sp. Figure 1.7

Description. A single fragmentary specimen of flattened longiconic orthocone was available for the study; it is approximately 16 mm in length and annulated(?); conch expansion very gradual. Shell surface marked by fine and closely spaced transverse lirae that exhibit weak sinus and form relatively broad salients; interspaces of lirae are narrow groove-like. No internal structure observable.

Material examined. IPMM 42351B.

Occurrence and age. This specimen was found in black shale at Senmatsu, Okago, Fujisawa-cho in Ichinoseki City, Iwate Prefecture. Judging from these lithologic and geographic evidences, its stratigraphic position is determinable as the upper part of the Senmatsu Formation (Ehiro, 1979; Ehiro and Bando, 1985). Fossils, including gastropods, bivalves, ammonoids and plants, suggest that the formation is Changhsingian in age (Murata, 1969; Kon'no, 1973; Bando, 1975; Murata and Shimoyama, 1979; Ehiro and Bando, 1985).

*Discussion*. Although surface ornamentation of the specimen corresponds to that of the genus *Neorthoceras*, its very gradual conch expansion is beyond the diagnosis of the generic type, *N. verbeeki* (Haniel, 1915, p. 140, 141, pl. 56, figs. 6a–c) from the Permian of East Timor, whose conch shows more rapid expansion and may attain 10° in angle.

# Genus and Species Indeterminate Figure 1.8

Description. A single deformed specimen was examined; it is a fragment of orthoconic phragmocone having 22 mm in length and smooth conch surface. Sutures directly transverse.



**Figure 1. 1–6.** *Cycloceras ofunatoense* sp. nov. 1, paratype, IGPS coll. cat. no. 112947, side view, silicon rubber cast: 2–5, holotype, IGPS coll. cat. no. 112948; 2, side view, silicon rubber cast; 3, 4, side views of Steinkern; 5, longitudinal section of Steinkern, showing annulations: 6, paratype, IGPS coll. cat. no. 112949, side view, silicon rubber cast. **7.** *Neorthoceras*? sp., IPMM 42351B, side view. **8.** Orthoconic cephalopod, genus and species indeterminate, IPMM 42351A, side view. Scale bar is 15 mm in 1, 5; 30 mm in 2–4, 6; 6 mm in 7; 20 mm in 8.

Septa shallow. Camerae short, ranging approximately 5–7 mm in length. Siphuncle can not observable.

Material examined. IPMM 42351A.

Occurrence and age. Same as Neorthoceras? sp. (this report).

*Discussion.* The present material is not complete to enough for a confident identification.

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