Columenoceras kyushuense, a new species of Silurian cephalopod from the Gionyama Formation in the Kuraoka area, Miyazaki Prefecture, Southwest Japan

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Abstract: A new Ludlow (early late Silurian) species of geisonoceratid orthocerid, *Columenoceras kyushuense*, is described from the G3 Member of the Gionyama Formation in the Kuraoka area of Miyazaki Prefecture, Southwest Japan. The new species differs from other species of *Columenoceras* by a combination of its narrow siphuncle, smooth shell surface, and relatively short to short camerae. This is the first record of *Columenoceras* outside Variscan Europe. The present discovery provides a further confirmation about the existence of a faunal linking between the Kurosegawa Belt and peri-Gondwana.

Introduction

The first Silurian cephalopod from the Gionyama Formation in the Kurosegawa Belt, Southwest Japan was reported by Hamada (1961), who discovered a geisonoceratid orthocerid, *Geisonocerina*? sp. Subsequently, Niko (2024) added four orthocerid and three pseudorthocerid species for the assemblage. The present study describes below a previously unrecorded orthocerid from the formation as *Columenoceras kyushuense* sp. nov.

Systematic paleontology

Subclass Orthoceratoidea Teichert, 1967 Order Orthocerida Kuhn, 1940 Family Geisonoceratidae Zhuravleva, 1959 Genus **Columenoceras** Barskov, 1960 Type species. Orthoceras columen Barrande, 1868.

Columenoceras kyushuense sp. nov. Figures 1.1–1.10

Diagnosis. Species of *Columenoceras* with smooth shell surface and relatively short to short camerae indicating form ratios (see below for definition) of 2–5; siphuncle subcentral and narrow; siphuncular diameter ratios (ditto) approximately 0.1–0.2; connecting rings cylindrical to subcylindrical; septal necks orthochoanitic to suborthochoanitic, short, 0.4–0.5 mm; endosiphuncular deposits form continuous lining on ventral siphuncular wall.

Description. Conchs longiconic orthocones with gradual expansion, 5°-6°, and circular transverse sections; the holotype of imperfect phragmocone has 70 mm length and diameters of 8.5 mm near apical and 11 mm at adoral ends; the largest paratype (phragmocone, IGPS coll. cat. no. 112849) attains approximately 13 mm in diameter; no shell surface observable by matrix, but sections suggest it is smooth and lacks distinct ornamentations. Septa exhibit deep curvature and form relatively short to short camerae, whose approximate ratios (maximum diameter per length) are 2-3 in apical and 2.5-5 in adoral phragmocones; there are 2-5 camerae in length of corresponding conch diameter; sutures also are not observable, but they indicate oblique and inclined towards dorsum natures in longitudinal section. Siphuncle subcentral in position, situated between the conch center and the ventral margin; siphuncular position ratios (distance of central axis of siphuncle from ventral shell surface per corresponding conch diameter) are approximately 0.4; in apical phragmocone, siphuncular wall consists of orthochoanitic septal necks and cylindrical connecting rings, then they shift suborthochoanitic and weakly inflated subcylindrical forms in adoral portions; lengths of septal necks are short, 0.4-0.5 mm, throughout; diameters of connecting rings narrow, 0.8-0.9 mm in apical (holotype) and attaining 1.4 mm in adoral (paratype, IGPS coll. cat. no. 112849) phragmocones; siphuncular diameter ratios (maximum siphuncular diameter per corresponding conch diameter) are approximately 0.1-0.2; thickening and structural differentiation are not developed in connecting rings. Cameral deposits well-developed and differentiated



into episeptal-mural and hyposeptal types; endosiphuncular deposits initially form as partial deposits, then they fuse with adjacent ones to form continuous lining on ventral siphuncular wall.

Material examined and repository. Holotype, IGPS coll. cat. no. 112950. Paratypes, IGPS coll. cat. nos. 112849, 112850, 112951, 112952. In addition, two specimens (IGPS coll. cat. nos. 112953, 112954) are also assigned to *Columenoceras kyushuense* sp. nov. These specimens are reposited in the Tohoku University Museum, Sendai.

Occurrence: All specimens examined herein were recovered from float blocks of limestones derived from the Ludlow (lower upper Silurian) G3 Member of the Gionyama Formation. Collecting site is a river bed of the Gokase River in the Kuraoka area, Miyazaki Prefecture. (= locality 5 in Niko, 2024).

Etymology. The specific name is derived from Kyushu Island, in which the type locality is situated.

Discussion. Columenoceras kyushuense sp. nov. is well differentiated from the typical species assigned to the genus by the possession of a narrow siphuncle. For example, its siphuncular diameter ratios are approximately 0.1-0.2, whereas this ratio reaches approximately 0.3 in the type species, C. columen (Barrande, 1868, pl. 309, figs. 8-11). Only C. duponti (Barrande, 1866, pl. 212, figs. 5-8; 1868, pl. 285, figs. 1-17, pl. 324, figs. 7-10; 1870, pl. 394, figs. 1-4) from the upper Silurian of Bohemia, Czech Republic and C. grande (Meneghini, 1857, p. 189-191, pl. C, figs 4A, a, a'; Gnoli, 1987, p. 246–248, pl. 1, figs. 1, a, 2, a, 3, a, b, 4, 5) from the upper Wenlock (upper lower Silurian) of Sardinia, Italy possess the relatively narrow siphuncles for the genus. However, the former species has prominent transverse bands on the shell surface and cameral lengths of the latter one are longer than those of C. kyushuense and indicate 1.2-1.4 in form ratios.

Significance

It has been considered that *Columenoceras* is an endemic genus in Variscan Europe, including Bohemia, Sardinia, Carnic Alps and Western Pyrenees, (Gnoli, 2002) whose area was a constituent of peri-Gondwana (northern margin of Gondwana) during late Silurian time (i.e., Scotese, 2001; Franke and Żelaźniewicz, 2023). This study represents the first record of the genus outside Variscan Europe. The existence of a linking of the cephalopod fauna between the Kurosegawa Belt and peri-Gondwana has been pointed out by Niko *et al.* (2017) and ratified subsequently by Niko (2021, 2024). The present discovery of *Columenoceras* from the Gionyama Formation belonging the Kurosegawa lends further support to the thoughts.

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Figure 1. *Columenoceras kyushuense* sp. nov., thin sections. **1–3, 9.** Holotype, IGPS coll. cat. no. 112950: 1, longitudinal section, venter on right; 2, transverse section, venter down, arrow indicates siphuncle; 3, partial enlargement to show siphuncular structure; 9, partial enlargement to show siphuncular wall structure, arrow indicates septal neck. **4, 5.** Paratype, IGPS coll. cat. no. 112951: 4, longitudinal section; 5, partial enlargement to show siphuncular structure, arrow indicates cameral endosiphuncular deposits. **6.** Paratype, IGPS coll. cat. no. 112952, longitudinal section, arrow indicates cameral deposits. **7, 8.** Paratype, IGPS coll. cat. no. 112849: 7, longitudinal section; 8, partial enlargement to show siphuncular structure. **10.** Paratypes, IGPS coll. cat. no. 112850, longitudinal section, showing details of siphuncular wall, arrow indicate suborthochoanitic septal neck. Scale bar is 10 mm in 1, 4, 6, 7; 6 mm in 2, 3; 3 mm in 5, 8; 0.6 mm in 9, 10.

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