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Silurian cephalopods from the Gionyama Formation in the Kuraoka area, Miyazaki Prefecture, Southwest Japan

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Abstract: Silurian longiconic cephalopods are described for the first time from the Gionyama Formation in the Kuraoka area, Miyazaki Prefecture, Southwest Japan. They include four orthocerids (*Michelinoceras* (*Michelinoceras*) *alticameratum* Kobayashi, 1984, *Kopaninoceras kobayashii* Niko, Hamada and Yasui, 1989, *Orthocycloceras* sp., *Arionoceras densiseptum* Kobayashi, 1983) and three pseudorthoceratids (*Haloites gionyamaensis* sp. nov., *Gordonoceras*? sp., *Subdoloceras* sp.). Except for *Subdoloceras* sp. that occurs from the Wenlock (upper lower Silurian) G2 and the Ludlow (lower upper Silurian) G3 members, their occurrences are restricted exclusively to the G3 Member. The new species is differentiated from the type species of *Haloites, H. bellus* Chen *in* Chen *et al.*, 1982, from the Wenlock in Hubei, Central China by its less eccentric siphuncular position. The Gionyama cephalopod assemblage belongs to the *Kopaninoceras* Fauna, whose main distributional area is the northern margin of Gondwana, as with the Yokokurayama and Suberidani assemblages in the Kurosegawa Belt.

Introduction

The Gionyama Formation in the Kuraoka area, Miyazaki Prefecture, Southwest Japan comprises an approximately 1400 m succession of Middle Paleozoic sedimentary rocks. Hamada (1959a) divided it into four members, namely G1 (sandstone with thin acidic tuff layers), G2 (limestone conglomerate with sandy to muddy matrixes), G3 (massive limestone), and G4 (sandstone, acidic tuff, conglomerate). Among them, the Wenlock (upper lower Silurian) G2 and Ludlow (lower upper Silurian) G3 members occur well-preserved fossils, including corals (i.e., Hamada, 1958; Kido, 2010; Niko and Adachi, 2013) and trilobites (Hamada, 1959b; Kobayashi and Hamada, 1987), that typify Silurian faunas in the Kurosegawa Belt.

This paper describes Silurian cephalopods from the Gionyama Formation for the first time. Following three localities in the Kuraoka area have yielded cephalopods (Figure 1). Locality 1 states the western foot of Mt. Gionyama and occurs diverse fossils from limestone conglomerate of the G2 Member. Locality 4 is a road side outcrop of sandstone belonging to the G2 Member, from which *Geisonocerina*? sp. was listed by Hamada (1961). This species is neither figured nor described until now, furthermore I cannot detect an additional material at the identical locality. Locality 5 is a river bed of the Gokase River near Kyowa, where many float blocks of limestones derived from the G3 Member are recognized.

Repository.—All examined specimens herein are housed in the Tohoku University Museum, Sendai (prefixed IGPS).

Cephalopod assemblage

The present Gionyama assemblage is composed by eight species of cephalopods, namely *Michelinoceras* (*Michelinoceras*) *alticameratum* Kobayashi, 1984, *Kopaninoceras kobayashii* Niko, Hamada and Yasui, 1989, *Orthocycloceras* sp., *Arionoceras densiseptum* Kobayashi, 1983, *Geisonocerina*? sp. (see Hamada, 1961; not confirmed in this study), *Haloites gionyamaensis* sp. nov., *Gordonoceras*? sp., and *Subdoloceras* sp. The latter three species are placed within the Order Pseudorthocerida that was not recorded previously in the Kurosegawa Belt. Not only *Kopaninoceras* but also *Michelinoceras*, *Orthocycloceras*, *Arionoceras* and *Subdoloceras* are the typical genera of the *Kopaninoceras* Fauna (Niko *et al.*, 2017) of which the main territory was the northern margin of Gondwana (peri-Gondwanan) including North Africa, Variscan Europe, southern Afghanistan, western Tibet, and Malaysia. This assemblage is one of the representatives of the fauna same as the Yokokurayama (Kobayashi, 1983, 1984, 1988; Kobayashi and Hamada, 1985; Niko *et al.*, 1989) and Suberidani (Niko, 2021) assemblages in the Kurosegawa Belt.

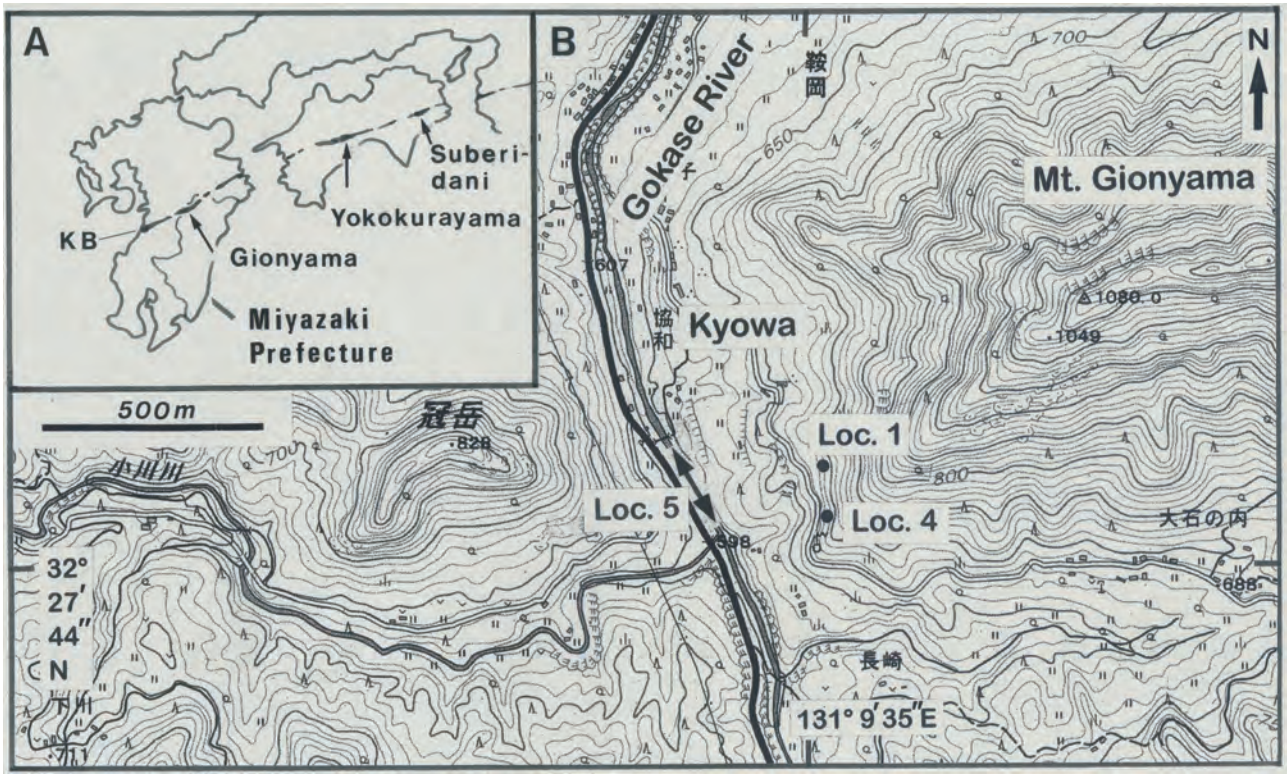

Figure 1. Map showing locations of the Kurosegawa Belt (KB), Miyazaki Prefecture, Gionyama, Yokokurayama and Suberidani in Southwest Japan (**A**), and cephalopod localities, 1, 4, 5 in the Kuraoka area (**B**). Used topographic map is "Digital Japan Basic Map" published by Geospatial Information Authority of Japan.

Systematic paleontology

Subclass Orthoceratoidea Teichert, 1967
Order Orthocerida Kuhn, 1940
Family Orthoceratidae M'Coy, 1844
Subfamily Michelinoceratinae Flower, 1945
Genus ***Michelinoceras*** Foerste, 1932
Type species.—*Orthoceras michelini* Barrande, 1866.
Subgenus ***Michelinoceras*** Foerste, 1932, emend. Kiselev and Gnoli, 1992

Michelinoceras (***Michelinoceras***) ***alticameratum***
Kobayashi, 1984

Figures 2.A, 2.B

Michelinoceras sp. α, sp. nov., Kobayashi, 1983, p. 293, fig. 1.

Michelinoceras alticameratum Kobayashi, 1984, p. 245, pl. 3, fig. 1; 1988, p. 1.

Michelinoceras (*Michelinoceras*) *alticameratum*; Niko, 2021, p. 2, 4, figs. 2.A–2.D, 2.G.

Description.—Conchs orthoconic with very gradual expansion and circular transverse sections; the largest specimen of imperfect phragmocone (IGPS coll. cat. no. 112840) attains 3 mm in approximate diameter; conch

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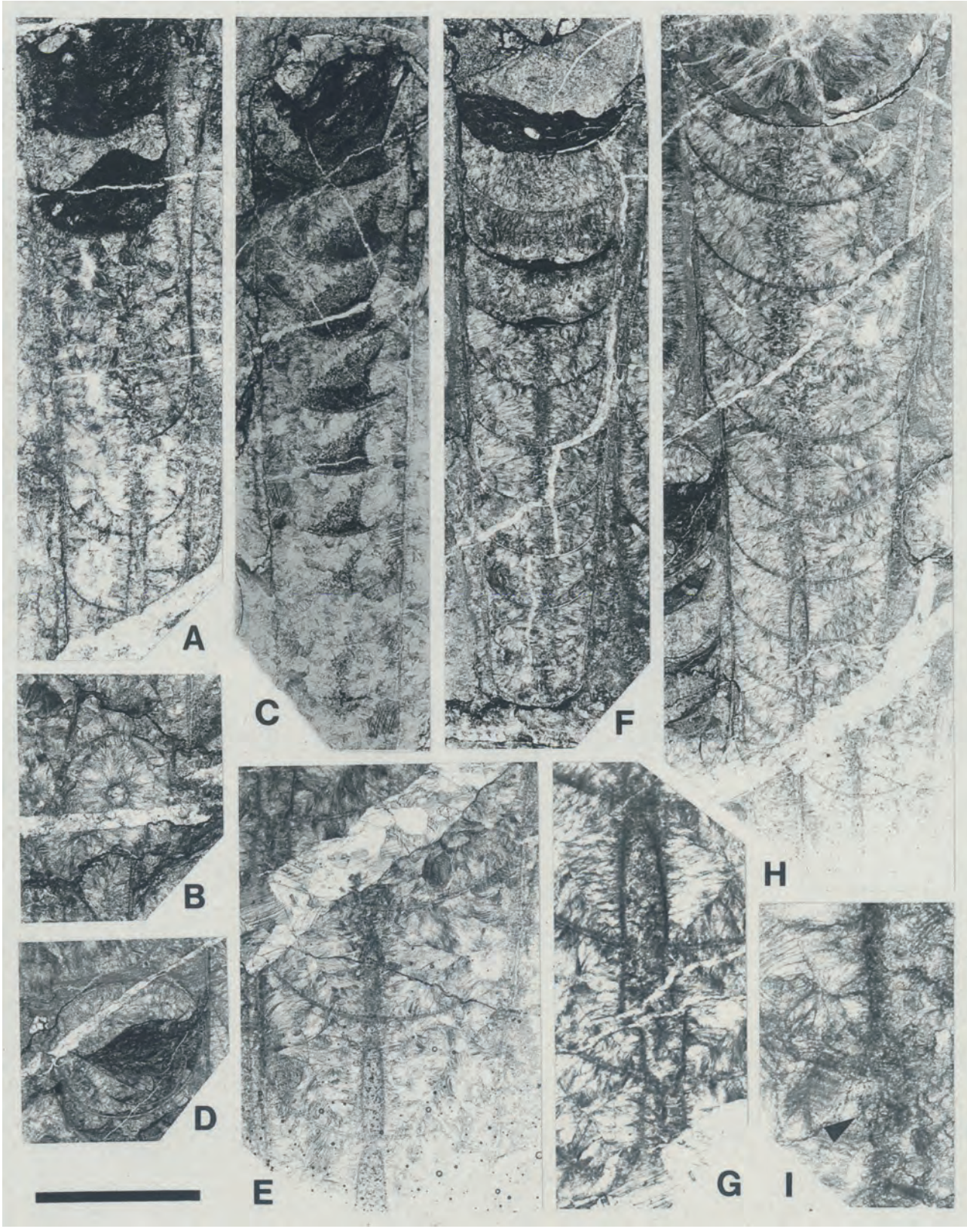
Figure 2. A, B. *Michelinoceras* (*Michelinoceras*) *alticameratum* Kobayashi, 1984, thin sections. A, IGPS coll. cat. no. 112838, longitudinal (slightly oblique) section: B, IGPS coll. cat. no. 112839, transverse section. **C–I**. *Arionoceras densiseptum* Kobayashi, 1983, thin sections. C, IGPS coll. cat. no. 112824, longitudinal (off siphuncle) section, note well-developed cameral deposits; D, IGPS coll. cat. no. 112827, transverse (slightly oblique) section: E, G–I, IGPS coll. cat. no. 112826: E, partial enlargement of H to show details of apical phragmocone; G, partial enlargement of H to show details of siphuncle; H, longitudinal (slightly oblique) section; I, partial enlargement of H to show details of septal neck (arrow): F, IGPS coll. cat. no. 112828, longitudinal section. Scale bar is 3 mm in A-C, E; 6 mm in D, F, H; 2.5 mm in G; 0.6 mm in I.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surface probably smooth; apex, adoral phragmocone and body chamber are missing. Camerae long to relatively long with form ratios (maximum width/length) of 1.1–1.6 and deeply concaved septa; sutures are possibly transverse. Siphuncle relatively large for the genus with ratios of siphuncular diameter per corresponding conch diameter attaining 0.15 and subcentral in position; connecting rings cylindrical; septal necks orthochoanitic and long. Cameral deposits are not observable.

Material examined.—IGPS coll. cat. nos. 112833, 112836, 112838–112840.

Occurrence.—All specimens examined herein occurred in limestone boulders at locality 5. Lithologically, these fossil-bearing limestones obviously belong to the Ludlow (lower upper Silurian) G3 Member of the Gionyama Formation.

Discussion.—*Michelinoceras* (*Michelinoceras*) *alticameratum* is a common constituent of the late Silurian faunas in the Kurosegawa Belt, Southwest Japan. It was first described by Kobayashi (1984) from the upper Fukada Formation of the Yokokurayama Group in Kochi Prefecture. Subsequently, this species discovered from the Suberidani Group in Tokushima Prefecture (Niko, 2021). There is a few tentative in the present specific identification of the Gionyama specimens because they are fragments of the apical phragmocones.

Genus ***Kopaninoceras*** Kiselev, 1969
Type species.—*Orthoceras jucundum* Barrande, 1870.

Kopaninoceras kobayashii Niko, Hamada and Yasui, 1989
Figures 3.A, 3.B

Kopaninoceras kobayashii Niko, Hamada and Yasui, 1989, p. 61, 63, figs. 2.A, 2.B; Niko, 2021, p. 4, figs. 2.E, 2.F, 2.H.

Description.—Conchs orthoconic with circular transverse sections; expansion of conch is relatively rapid for the order, approximately 9°; the largest specimen of imperfect phragmocone (IGPS coll. cat. no. 113837) attains 5.5 mm in approximate diameter; conch surface probably smooth; apex and body chamber are missing. Camerae relatively long to moderate with form ratios (maximum width/length) of 1.4–1.9; septa relatively deep; sutures faintly oblique to possibly transverse. Siphuncle narrow and composed by cylindrical connecting rings and long orthochoanitic septal necks; position of siphuncle is subcentral. Cameral deposits are episeptal-mural and hyposeptal.

Material examined.—IGPS coll. cat. nos. 112823, 112830, 112832, 112834, 112837.

Occurrence.—All examined specimens were collected from float blocks of limestones derived from the Ludlow G3 Member at locality 5.

Discussion.—*Kopaninoceras kobayashii* is also a typical species in the Kurosegawa late Silurian cephalopod assemblages. It commonly occurs in the Yokokurayama and Suberidani groups in Southwest Japan (Niko *et al*., 1989; Niko, 2021).

Subfamily Leurocycloceratinae Sweet, 1964
Genus ***Orthocycloceras*** Barskov, 1972
Type species.—*Orthocycloceras alayense* Barskov, 1972.

Orthocycloceras sp.
Figures 3.C, 3.D

Description.—Longiconic and annulated orthocones with circular transverse sections; conch expansion gradual. Camerae short with form ratios (maximum width/length) of 3.1–5.2; septa shallow. Siphuncle central with cylindrical connecting rings and short orthochoanitic septal necks. Cameral deposits episeptal-mural.

Material examined.—IGPS coll. cat. nos. 112819, 112820, 112831, 112835.

Occurrence.—All examined specimens were collected from float blocks of limestones derived from the Ludlow G3 Member at locality 5.

Discussion.—There is a possibility that the present Gionyama specimens are conspecific with *Orthocycloceras* sp. (Niko, 2021, p. 4, figs. 2.I–2.K) described from the Suberidani Group. Unfortunately, they are inadequate to determinate, because their well-oriented section through the central axis of the siphuncle was not available.

Family Arionoceratidae Dzik, 1984
Genus ***Arionoceras*** Barskov, 1966
Type species.—*Orthoceras arion* Barrande, 1866.

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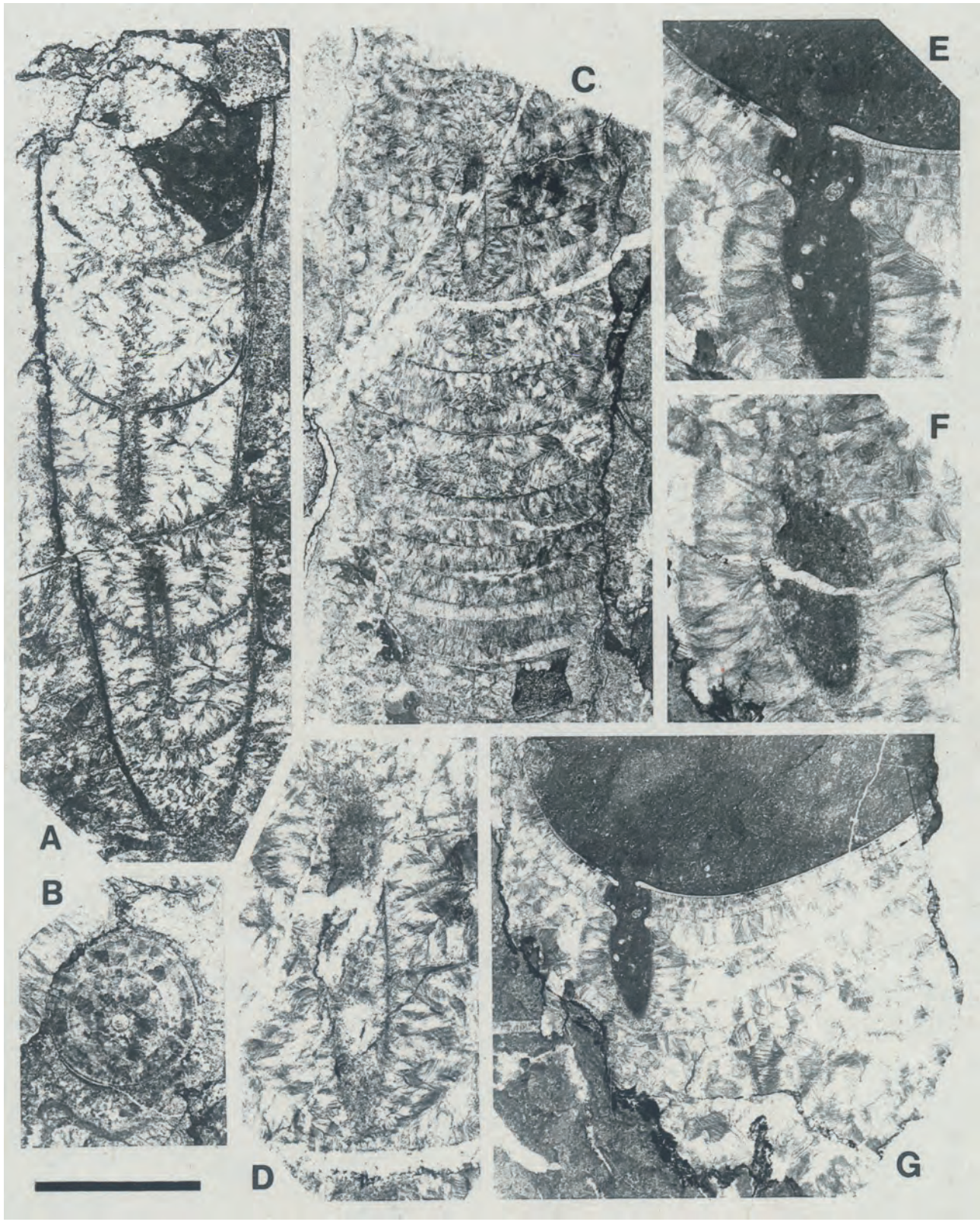
Figure 3. A, B. *Kopaninoceras kobayashii* Niko, Hamada and Yasui, 1989, thin sections. A. IGPS coll. cat. no. 112830, longitudinal (slightly oblique) section: B. IGPS coll. cat. no. 112837, transverse section. **C, D.** *Orthocycloceras* sp., IGPS coll. cat. no. 112820, thin sections. C, longitudinal (slightly oblique) section: D, partial enlargement of C to show details of siphuncle. **E–G.** *Gordonoceras*? sp., IGPS coll. cat. no. 112822, thin sections. E, F, partial enlargements of G to show details of siphuncle: G, longitudinal (slightly oblique) section. Scale bar is 3 mm in A, B, E, F; 6 mm in C, G; 2.5 mm in D.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Arionoceras densiseptum Kobayashi, 1983
Figures 2.C–2.I

Arionoceras densiseptum Kobayashi, 1983, p. 293, fig. 5; 1984, p. 246, 247, pl. 3, figs. 3–5; The Tokai Fossil Society, 1995, p. 48, upper fig.

Description.—Conchs longiconic orthocones with slightly elliptical (dorsoventrally depressed?) transverse sections; expansion angles of conchs are relatively large for the order, ranging from 5° to 8°; the largest specimen of imperfect phragmocone (IGPS coll. cat. no. 112826) attains 9 mm in approximate diameter; conch surface probably smooth; apex and body chamber are missing. Camerae moderate to short with form ratios (maximum width/length) of 2.0–3.2; septal curvature moderate; sutures slightly oblique leaning toward the dorsum. Siphuncle shifts to the venter and subcentral in position; siphuncular walls composed by short orthoconic septal necks and nearly cylindrical connecting rings. Cameral deposits are episeptal-mural and hyposeptal, but developments of the latter deposits are partial and restricted to the ventral side.

Material examined.—IGPS coll. cat. nos. 112824–112829.

Occurrence.—All examined specimens were collected from float blocks of limestones derived from the Ludlow G3 Member at locality 5.

Discussion.—Characteristics of the examined six specimens from the Gionyama Formation are quite identical with those of *Arionoceras densiseptum*, whose type locality is the upper Fukada Formation. This discovery represents the first record of the species except for the Yokokurayama Group.

Order Pseudorthocerida Barskov, 1963
Family Pseudorthoceratidae Flower and Caster, 1935
? Subfamily Pseudorthoceratinae Flower and Caster, 1935
Genus ***Haloites*** Chen *in* Chen, Liu and Chen, 1981

Type species.—*Haloites bellus* Chen *in* Chen, Liu and Chen, 1981.

Haloites gionyamaensis sp. nov.
Figures 4.A–4.F

Diagnosis.—Longiconic pseudorthoceratid with gently exogastric cyrtocone in apical and orthocone in adoral parts; conch expansion gradual; camerae short; siphuncle near central with position ratio of 0.55; siphuncular segments subglobose to pyriform; septal necks cyrtochoanitic; cameral deposits mural and hyposeptal; annulosiphonate endosiphuncular deposits indicate subtriangular protrusion.

Description.—An only available specimen that designated herein the holotype is longicone with circular transverse section and consists of imperfect phragmocone and apical body chamber; its apical part exhibits gentle exogastric curvature and adoral one is orthoconic; measurements of the holotype are 69 mm in preserved length, 15 mm in maximum observable diameter, and 33 mm in preserved length of body chamber; conch expansion gradual indicating approximately 4° at phragmocone; body chamber may exhibit weak constriction; detailed character of shell surface unknown because it embedded in matrix, but distinct ornamentation is not detected in longitudinal and transverse sections; apex and peristome are missing. Camerae short indicating 3.0–3.4 in form ratio (maximum width/length); septa shallow; in observations of longitudinal sections, sutures seem transverse. Siphuncle nearly central, but faint shifts to dorsum in position with siphuncular position ratio (minimum distance from ventral shell surface to central axis of siphuncle/corresponding conch diameter) of 0.55; siphuncular wall composed by short cyrtochoanitic septal necks and strongly inflated connecting rings; septal neck shapes asymmetrical indicating hook-like in ventral side with approximately 0.6 mm in brim length and simple cyrtochoanitic in dorsal side with 0.3–0.4 mm in ditto; longitudinal profiles of segments are subglobose to pyriform with form rations (maximum width/length) of 0.8–1.0; connecting rings undifferentiated in structure, but slightly thickened attaining 0.08 mm. Cameral deposits well-developed and differentiated into mural and hyposeptal types; endosiphuncular deposits annulosiphonate, slightly thicker in ventral side than in dorsal one, and microgranular in structure; longitudinal section of well-preserved endosiphuncular deposits indicates subtriangular protrusion on adoral surface of septum.

Material examined.—Holotype, IGPS coll. cat. no. 112818.

Occurrence.—The holotype occurred in flat block of limestone deriving from the G3 Member of the Gionyama Formation. The fossil-bearing block was collected from the riverbed at locality 5.

Etymology.—The specific name is derived from the type stratum.

Discussion.—The present species from the Gionyama Formation is tentatively assigned to an insufficiently diagnosed genus *Haloites*, because its gross conch shape and siphuncular structure are similar to those of the generic type, *H. bellus* Chen (*in* Chen *et al*., 1982, p. 44, 45, pl. 10, figs. 14, 15), described from the Wenlock Xiushan Formation in Hubei, Central China, and as far as I know there is no comparable Silurian genus with it. These two species can be distinguished by their siphuncular position rations, i.e., 0.55 in the Gionyama species versus 0.57–0.63 in *H. bellus*. These numeral values indicate less eccentric siphuncular position in the former than the latter. Therefore, the author

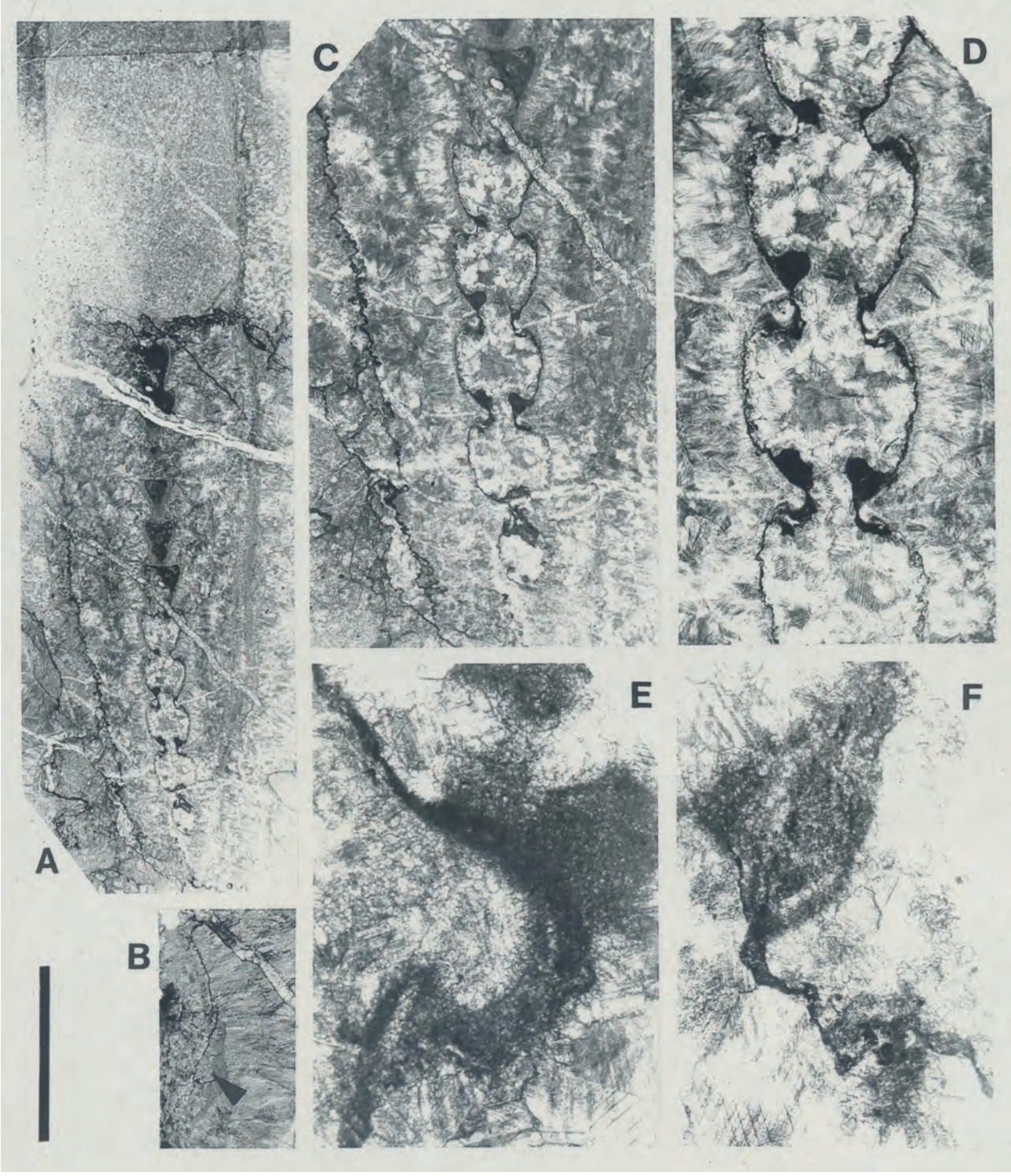

Figure 4. *Haloites gionyamaensis* sp. nov., holotype, IGPS coll. cat. no. 112818, thin sections. **A**, longitudinal section, venter on left. **B,** transverse section of body chamber (arrow). **C, D,** partial enlargements of A to show details of siphuncle. **E,** partial enlargements to show details of ventral septal neck. **F,** partial enlargements to show details of dorsal septal neck. Scale bar is 12 mm in A; 6 mm in B, C; 3 mm in D; 0.6 mm in E, F.

advocates a new species as *H. gionyamaensis* even though some unclear points concerning the generic placement still remain.

The exogastric curvature of the apical shell and the subglobular siphuncular segments of *Haloites gionyamaensis* are also recognized in the Devonian to Carboniferous pseudactinoceratine pseudorthocerids, such as *Pseudactinoceras* Schindewolf, 1943, *Campyloceras* M'Coy, 1844, and *Macroloxoceras* Flower, 1957. However, these siphuncles are distinctly ventral from the central axis of the conch. There is a possibility that *Haloites* and genera of the subfamily Pseudactinoceratinae Schindewolf, 1943, are phylogenetically related.

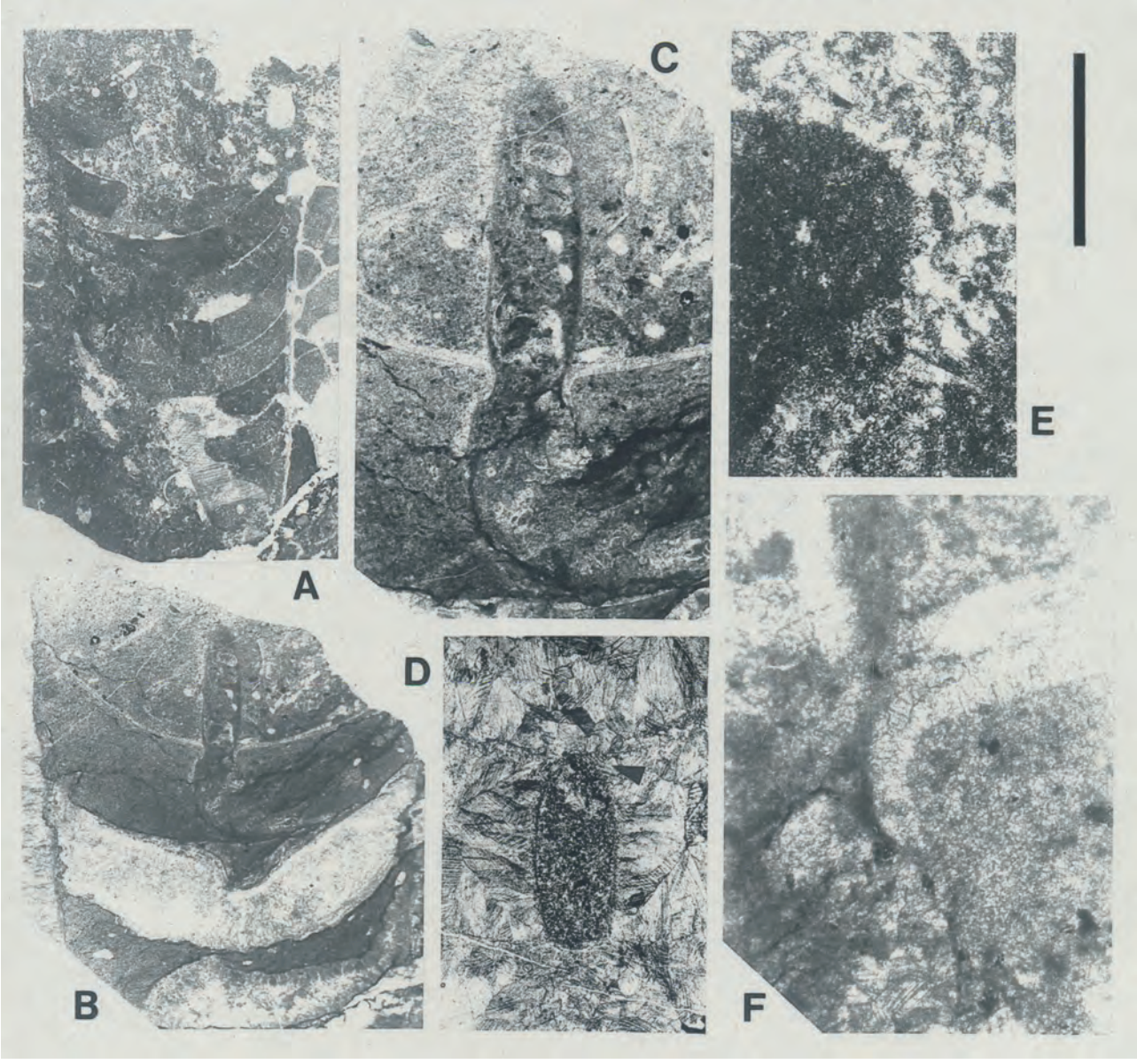

Figure 5. *Subdoloceras* sp., thin sections. **A, D, E,** IGPS coll. cat. no. 112817: A, longitudinal (slightly oblique) section; D, longitudinal (slightly oblique) section, showing details siphuncle, arrow indicates septal neck; E, partial enlargement of A to show details of septal neck. **B, C, F,** IGPS coll. cat. no. 112821: B, longitudinal (slightly oblique) section; C, partial enlargement of B to show details of siphuncle; F, partial enlargement of B to show details of septal neck. Scale bar is 6 mm in A, B; 3 mm in C, D; 0.6 mm in E, F.

Subfamily Spyroceratinae Shimizu and Obata, 1935

Genus ***Gordonoceras*** Teichert and Glenister, 1953

Type species.—*Gordonoceras bondi* Teichert and Glenister, 1953.

Gordonoceras? sp.

Figures 3.E–3.G

Description.—A single fragment of longiconic cyrtocone is available for this study; it consists of adoral phragmocone with the last septum and apical body chamber; conch diameter attains at least 16.5 mm. Camerae very short; septal curvature deep. Siphuncle situates near midway between conch axis and margin; septal neck achoanitic in the last septum and cyrtochoanitic to suborthochoanitic in the second one from the last; connecting rings more or less inflated. No endosiphuncular and cameral deposits preserved.

Material examined.—IGPS coll. cat. no. 112822.

Occurrence.—This specimen was collected in flat block of limestone deriving from the Ludlow G3 Member at locality 5.

Discussion.—In its general conch shape and siphuncular position, the fragment is suggestive of *Gordonoceras*, whose type species was described from the Silurian of Tasmania (Teichert and Glenister, 1953), but is not complete to enough for a confident identification.

Genus ***Subdoloceras*** Krōger, 2008

Type species.—*Subdoloceras tafilaltense* Krōger, 2008.

Subdoloceras sp.

Figures 5.A–5.F

Description.—Two fragmentary phragmocones are available in this study; they are longiconic orthocones with moderate expansion for the order and circular transverse sections; the larger specimen (IGPS coll. cat. no. 112821) attains 12 mm in conch diameter. Camerae short, having maximum width per length ratios of 3.1–4.8; septa deeply concaved and form oblique sutures. Siphuncle subcentral in position; septal necks suborthochoanitic, short; connecting rings mostly cylindrical with abrupt constrictions at septal foramina. No endosiphuncular and cameral deposits preserved.

Material examined.—IGPS coll. cat. nos. 112817, 112821.

Occurrence.—A specimen (IGPS coll. cat. no. 112817) was collected from limestone pebble in limestone conglomerate belonging to the Wenlock (late early Silurian) G2 Member at locality 1. Another specimen (IGPS coll. cat. no. 112821) occurs in flat block of limestone deriving from the Ludlow G3 Member at locality 5.

Discussion.—The Gionyama specimens display similarities to *Subdoloceras* that was previously known from the Pragian to upper Emsian (Lower Devonian) of Morocco (Krōger, 2008), especially in their cameral length and siphuncular structure. However, the fragmentary nature of the present species prevents identification in the specific level.

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References

Barskov, I. S., 1963, System and phylogeny of pseudorthoceratids. *Biulleten Moskovskogo Obshchestva Ispytatelei Prirody*, *Otdel Geologicheskii*, vol. 38, p. 149, 150. (in Russian)

Barskov, I. S., 1966, *Cephalopods of Late Ordovician and Silurian of Kazakhstan and Middle Asia*, 200 p. Avtoreferat Dissertatsii na Soiskanie Uchenoi Stepeni Kandidata Geologo-Mineralogicheskikh Nauk. Izdatel'stovo Moskovskogo Universitete, Moscow. (in Russian)

Barskov, I. S., 1972, *Late Ordovician and Silurian cephalopod mollusks of Kazakhstan and Middle Asia*, 112 p. Akademia Nauk SSSR, Moscow. (in Russian)

Barrande, J., 1866, *Système Silurien du Centre de la Bohême*, *Première Patie: Recherches Paléontologiques*, *Volume 2*, *Classe des Mollusques*, *Ordre des Céphalopodes*, *2me Série*, pls. 108–244. Prague and Paris.

Barrande, J., 1870, *Système Silurien du Centre de la Bohême, Première Patie: Recherches Paléontologiques*, *Volume 2*, *Classe des Mollusques*, *Ordre des Céphalopodes*, *4me Série*, pls. 351–460. Prague and Paris.

Chen, J., Liu, G. and Chen, T., 1981, Silurian nautiloid faunas of Central and Southwestern China. *Memoirs of Nanjing Institute of Geology and Palaeontology*, no. 13, p. 1–104, pls. 1–40. (in Chinese with English abstract)

Dzik, J., 1984, Phylogeny of the Nautiloidea. *Palaeontologia Polonica*, no. 45, p. 1–219, pls. 1–47.

Flower, R. H., 1945, Classification of Devonian nautiloids. *The American Midland Naturalist*, vol. 33, p. 675–724, pls. 1–5.

Flower, R. H., 1957, *Studies of the Actinocerida*, 100 p., 13 pls. State Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology Campus Station, Memoir 2, Socorro, New Mexico.

Flower, R. H. and Caster, K. E., 1935, The stratigraphy and paleontology of northwestern Pennsylvania. Part II: Paleontology. Section A: The cephalopod fauna of the Conewango Series of the Upper Devonian in New York and Pennsylvania. *Bulletins of American Paleontology*, vol. 22, p. 199–271.

Foerste, A. F., 1932, Black River and other cephalopods from Minnesota, Wisconsin, Michigan, and Ontario (Part I). *Denison University Bulletin*, *Journal of the Scientific Laboratories*, vol. 27, p. 47–136, pls. 7–37.

Hamada, T., 1958, Japanese Halysitidae. *Journal of the Faculty of Science*, *the University of Tokyo*, *Section 2*, vol. 11, p. 91–114, pls. 6–10.

Hamada, T., 1959a, Gotlandian stratigraphy of the Outer Zone of Southwest Japan. *The Journal of the Geological Society of Japan*, vol. 65, p. 688–700. (in Japanese with English abstract)

Hamada, T., 1959b, Gotlandian shelly fauna from Southwest Japan (I). *Coronocephalus kobayashii*, a new species from the Kuraoka district, Kyûshû. *Japanese Journal of Geology and Geography*, vol. 30, p. 71–88, pl. 6.

Hamada, T., 1961, The Middle Palaeozoic group of Japan and its bearing on her geological history. *Journal of the Faculty of Science*, *the University of Tokyo*, *Section 2*, vol. 13, p. 1–79.

Kido, E., 2010, Silurian rugose corals from the Kurosegawa Terrane, Southwest Japan, and the first occurrence of *Neobrachyelasma*. *Journal of Paleontology*, vol. 84, p. 466–476.

Kisselev, G. N., 1969, Silurian cephalopods of the Bol'shezemel'skaya Tundra of the northern Urals. *Avtoreferat Kandidat Dissertatsiya*, *Izdatel'stovoLeningradskogo Universiteta*, *Leningrad*, p. 1–22. (in Russian)

Kisselev, G. N. and Gnoli, M., 1992, About revision of the genus *Michelinoceras* Foerste, 1932 (Cephalopoda). *Vestnik Sankt-Petersburgoko Universiteta*, *Series 7*, vol. 2, p. 74, 75. (in Russian)

Kobayashi, T., 1983, On the Silurian cephalopod faunule from Mt. Yokokura, Kochi Prefecture, Shikoku, Japan. *Proceedings of the Japan Academy*, *Series B*, vol. 59, p. 293–295.

Kobayashi, T., 1984, Silurian cephalopods from Yokokura-yama, Kochi Prefecture, Japan. *Research Reports of the Kôchi University*, vol. 32, p. 240–251, pls. 3, 4.

Kobayashi, T., 1988, The Silurian cephalopods and trilobites from the Yokokurayama Formation, Shikoku, Japan. *Proceedings of the Japan Academy*, *Series B*, vol. 64, p. 1–8.

Kobayashi, T. and Hamada, T., 1985, On the Silurian trilobites and cephalopods of Mt. Yokokura, Shikoku, Japan. *Proceedings of the Japan Academy*, *Series B*, vol. 61, p. 345–347.

Kobayashi, T. and Hamada, T., 1987, Silurian trilobites of Japan: In comparison with Asian, Pacific and other areas. *Palaeontological Society of Japan*, *Special Papers*, no. 18, p. 1–155, pls. 1–12.

Kröger, B., 2008, Nautiloids before and during the origin of ammonoids in a Siluro-Devonian section in the Tafilalt, Anti-Atlas, Morocco. *The Palaeontological Association*, *Special Papers in Palaeontology*, no. 79, p. 1–110.

Kuhn, O., 1940, *Paläozoologie in Tabellen*, 50 p. Fischer, Jena.

M'Coy, F., 1844, *A Synopsis of the Characters of the Carboniferous Limestone Fossils of Ireland*, 274 p. Privately published. (reissued by Williams and Norgate, London, 1862)

Niko, S., 2021, Late Silurian orthocerid cephalopods from the Suberidani Group, Tokushima Prefecture, Southwest Japan. *Bulletin of the Tohoku University Museum*, no. 20, p. 1–7.

Niko, S. and Adachi, T., 2013, Silurian halysitids (Coelenterata: Tabulata) from the Gionyama Formation, Miyazaki Prefecture, Japan. *Bulletin of the National Museum of Nature and Science*, vol. 39, p. 17–41.

Niko, S., Hamada, T. and Yasui, T., 1989, Silurian Orthoceratacеae (Mollusca: Cephalopoda) from the Yokokurayama Formation, Kurosegawa Terrane. *Transactions and Proceedings of the Palaeontological Society of Japan*, *New Series*, no. 154, p. 59–67.

Niko, S., Sone, M. and Leman, M. S., 2017, Silurian cephalopods from Langkawi, Malaysia, with peri-Gondwanan faunal affinity. *Journal of Systematic Paleontology*, vol. 16, p. 595–610.

Schindewolf, O., 1943, Über das Apikalende der Actinoceren (Cephl., Nautil.). *Jahrbuch des Reichsamt für Bodenforschung für das Jahr 1941*, vol. 62, p. 207–247, pls. 8–11.

Shimizu, S. and Obata, T., 1935, New genera of Gotlandian and Ordovician nautiloids. *The Journal of the Shanghai Science Institute*, *Section 2*, vol. 2, p. 1–10.

Sweet, W. C., 1964, Nautiloidea—Orthocerida. *In*, Teichert, C., Kummel, B., Sweet, W. C., Stenzel, H. B., Furnish, W. M., Glenister, B. F., Erben, H. K., Moore, R. C. and Nodine Zeller, D. E., *Mollusca 3*, *Cephalopoda General Features*, *Endoceratoidea*, *Actinoceratoidea*, *Nautiloidea & Bactritoidea*. Moore, R. C. *ed*., *Treatise on Invertebrate Paleontology*, *Part K*, p. K216–K261. Geological Society of America, New York, and University of Kansas Press, Lawrence.

Teichert, C. 1967, Major features of cephalopod evolution. *In*, Teichert, C. and Yochelson, E. L. *eds*., *Essays in Paleontology & Stratigraphy. R. C. Moore Commemorative Volume*, *Department of Geology*, *University of Kansas Special Publication 2*, p. 162–210. The University Press of Kansas, Lawrence and London.

Teichert, C. and Glenister, B. F., 1953, Ordovician and Silurian cephalopods from Tasmania, Australia. *Bulletins of American Paleontology*, vol. 34, p. 1–66, pls. 1–6.

Tokai Fossil Society, 1995, *Fossils*, *Field Selection 20*, 256 p., Hokuryukan, Tokyo. (in Japanese)