Late Devonian (Famennian) brachiopods from Takaya, Bungo-ono City, Oita Prefecture, in the Kurosegawa Belt of Kyushu, southwestern Japan

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Abstract: Two Devonian brachiopod species, *Spinocyrtia* sp. and *Strophopleura notabilis* (Kindle), are here described from the newly proposed Takaya Formation of Takaya, Bungo-ono City, Oita Prefecture, in the Kurosegawa Belt of Kyushu, southwestern Japan. This is the first record, with systematic descriptions, of Devonian brachiopods from Kyushu. The Takaya fauna indicates a Late Devonian (Famennian) age. The Takaya Formation is thereby correlated with the Famennian formations of the Kurosegawa, South Kitakami and Hida Gaien belts in Japan.

Stratigraphy and Collections

The stratigraphy of the Palaeozoic–Mesozoic rocks in the Takaya area was studied by Sakai et al. (1993), Hoshizumi et al. (2015) and Sato et al. (2018). According to Sato et al. (2018) and unpublished data of the present authors (Y. Sato, T. Aso and T. Sugiyama), the fossil bearing sandstone–shale unit is distributed in an area of approximately 200 m (E–W) × 40 m (N–S) on the southwestern slope of Mt. Ohirayama, and only a 25 m long section is exposed along a pass on an inclined surface near the end of the Ichinouchi Path (Fig. 1C). The strata strike from N75°W to N80°E (E–W in average) dip 68°N to 78°N (are overturned), and are composed of black shale in the lower half and dark grey fine to medium-grained sandstone in the upper half, the total thickness is more than 20 m (Fig. 2). In this paper, we propose the name Takaya Formation for the sandstone–shale unit in the Takaya area. The Takaya Formation is corresponding to one of the exotic blocks in the Jurassic (Sakai et al., 1993) or Permian (Hoshizumi et al., 2015) Uchiyama Formation and the lowest sandstone–mudstone beds (20 m thick) underlying the unnamed Carboniferous limestone (Sato et al., 2018). The Takaya Formation is probably in fault contact with the Silurian Okuhata Formation (Noda, 1961), and is overlain unconformably by the unnamed Carboniferous limestone (Sato et al., 2018).

Brachiopods described herein were collected by Y. Sato from the upper part of sandstone of the Takaya Formation at locality OH107 (32°58′22″N, 131°38′00″E) as shown in Fig. 1B and Fig. 2. The brachiopods occur with casts of solitary corals, cavities of crinoid stems, and bivalve shells, but many are deeply weathered. The
brachiopod specimens are now registered and stored in the Kitakyushu Museum of Natural History and Human History, Kitakyushu (prefix KMNH IvP, numbers 700036–700038).

The Takaya fauna

The Takaya fauna consists of two species in two genera, *Spinocyrtia* sp. and *Strophopleura notabilis* (Kindle, 1909). Of these species, *Strophopleura notabilis* has been described or figured from the Famennian of the South Kitakami Belt, northeastern Japan (Minato, 1952; Tachibana, 1964; Minato et al., 1979; Tazawa, 2018) and New Mexico, the USA (Kindle, 1909; Stainbrook, 1947; Cooper and Dutro, 1982). *Spinocyrtia* is known from the Middle–Upper Devonian of North America, central Russia (Kuznetsk Basin) and Kazakhstan (Ivanova, 1962). Based on these data, it is concluded that the Takaya fauna is Famennian in age. Palaeobiographically, it is noteworthy that *Strophopleura notabilis* has been described from the Famennian of the South.

Fig. 1. Location and geology of the Takaya area, Mie-machi, Bungo-ono City, Oita Prefecture. A, Geotectonic map of Kyushu (modified from Saito et al., 2005) showing the Palaeozoic rocks the Kurosegawa Belt in black between the Usuki–Yatsushiro Tectonic Line and the Butsuzu Tectonic. B, Topographic map of the Takaya area showing fossil locality OH107 (using the 1:25,000 topographic map "Haidatesan", Geospatial Information Authority of Japan). C, Geological map of the Takaya area, showing fossil locality OH107 and the distribution of the Takaya Formation and associated formations (modified from Sato et al., 2018).
Kitakami Belt (Choanji and Nagasaka), northeastern Japan.

Discussion

In previous work, the fossil-bearing sandstone–shale unit of the Takaya Formation was not assigned to the Kurosegawa Belt, owing to no fossil evidence from the unit. Sakai et al. (1993) and Hoshizumi et al. (2015) regarded the sandstone–shale unit as one of the Palaeozoic blocks in the Permian or Jurassic accretionary complex. Sato et al. (2018) considered the sandstone–shale unit as the lowest part of the sandstone–shale–limestone sequence of the Carboniferous (Mississippian–lower Pennsylvanian). However, we conclude that the sandstone–shale unit, herein defined as the Takaya Formation, is a member of the Kurosegawa Belt in the Takaya area, together with the adjoining Silurian Okuhata Formation and the unnamed Carboniferous limestone, on the basis of the Devonian brachiopod fossils.

The age of the Takaya Formation is assigned to the Famennian on the basis of the two brachiopod species (Spinocyrtia sp. and Strophopleura notabilis) described herein. Therefore, the Takaya Formation is correlated with the Naidaijin Formation (Miyamoto and Tanimoto, 1993), Yamaide Formation (Saito et al., 2005) and Ochi Formation (Hirata, 1966a, 1966b) in the Kurosegawa Belt of Kyushu and Shikoku, southwestern Japan; the Senjogataki Formation (Okami et al., 1987), Choanji Formation (Tazawa and Niikawa, 2018), Tobigamori Formation (Noda, 1934) and Ainosawa Formation (Sato, 1956) in the South Kitakami Belt, northeastern Japan; and the Rosse Formation (Tazawa et al., 2000) in the Hida Gaien Belt, central Japan.

Systematic descriptions

(by J. Tazawa)

Order Spiriferida Waagen, 1883
Suborder Spiriferidina Waagen, 1883
Superfamily Cyrtospiriferoida Termier and Termier, 1949
Family Spinocyrtiidae Ivanova, 1959
Genus Spinocyrtia Fredericks, 1916

Type species. – Delthyris granulosa Conrad, 1839.

Spinocyrtia sp.

(Fig. 3A, B)

Material. – Two specimens: (1) internal mould of a composite shell, with external mould of the dorsal valve, KMNH IvP 700036; and (2) external and internal moulds of a ventral valve, KMNH IvP 700037.

Description. – Shell medium in size for genus, transversely subrectangular in outline, with greatest width at hinge; length about 32 mm, width about 48 mm in the better preserved specimen (KMNH IvP 700036). Ventral valve moderately and unevenly convex in lateral profile, most convex in umbonal region; sulcus deep and broad, with U-shaped bottom, and ornamented with a few weak costae. Dorsal valve more strongly convex than ventral valve; fold high and broad, with rounded crest, and ornamented with a few weak costae. External surface of both valves ornamented with numerous strong simple costae and some irregular concentric rugae on lateral slopes and extremely fine, closely spaced growth lines with very fine granules on the surface of both valves; 5–6 costae in 10 mm at midlength of ventral valve; 6–7 costae in 10 mm at midlength of dorsal valve. Internal structures of both valves not well preserved, except for a prominent muscle scar in ventral valve.

Remarks. – These specimens are safely assigned to the genus Spinocyrtia by the large, biconvex and transverse shell, with prominent fold and sulcus, and the external ornament of both valves consisting of numerous strong simple costae on the lateral slopes and very fine growth lines and granules on the surface of both valves. The Takaya species resembles the type species, Spinocyrtia granulosa (Conrad, 1839), redescribed by Ehlers and Wright (1955, p. 6, pl. 1, figs. 4–9; pl. 2, figs. 1, 2; pl. 3) from the Ludlowville Formation (Middle Devonian) of southwestern Ontario, Canada, in general shape.
of the shell and external ornament of the both valves, but differs from S. granulosa in the smaller size. Spinocyrtia parvigranulata Ehlers and Wright (1955, p. 12, pl. 4, figs. 5–11; pl. 5, fig. 3), from the Widden Formation (Middle Devonian) of southwestern Ontario, Canada, differs from the present species in having a shallow median depression in the ventral sulcus and dorsal fold. The Takaya species may be a new species, but the poorly preserved specimens preclude that determination.

Superfamily Paeckelmanelloidea, Ivanova, 1972
Family Strophopleuridae Carter, 1974
Subfamily Strophopleurinae Carter, 1974
Genus Strophopleura Stainbrook, 1947

Type species. — Spirifer notabilis Kindle, 1909.

Strophopleura notabilis (Kindle, 1909) (Fig. 3C)

*Spiriferina* paratransversa Minato, Minato et al., 1979, pl. 18, figs. 1, 2.

**Material.** — One specimen, external mould of a ventral valve, KMNH IvP 700038.

**Description.** — Shell medium in size for genus, transversely fusiform in outline, widest at hinge; cardinal extremities mucronate; length 9 mm, width about 25 mm. Ventral valve moderately convex in lateral profile; umbo small; sulcus narrow, deep, with prominent sulcus-bounding costae. External surface of ventral valve ornamented with numerous simple costae and regular concentric lamellae; with 6–7 costae on each lateral flank; 5–6 lamellae in 2 mm.

**Remarks.** — The only specimen is an external mould of a ventral valve, information on internal structure of the ventral valve and on external and internal characters of the dorsal valve are lacking. However, this specimen can be referred to *Strophopleura notabilis* (Kindle, 1909, p. 26, pl. 7, figs. 3–6), from the Percha Formation (upper Famennian) of Hillsboro, New Mexico, the USA, based on the size, shape and external ornament of the ventral valve. The two spiriferid species from the Famennian beds of the South Kitakami Belt, northeastern Japan, *Spiriferina paratransversa* Minato (1952, p. 161, pl. 7, fig. 4; pl. 8, fig. 2) from the Hikoroichi Series (= Choanji Formatin of Tazawa and Niikawa, 2018) of Choanji and *Iwaispirifer striatolamellosus* Tachibana (1964, p. 42, fig. 4) from the Tobigamori Formation of
Nagasaki, are deemed to be junior synonyms of the present species.

**Distribution**.—Famennian: northeastern Japan (Choanji and Nagasaki in the South Kitakami Belt), southwestern Japan (Takaya in the Kurosegawa Belt) and the USA (New Mexico).

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**References**

Carter, J. L., 1974, New genera of spiriferid and brachythridid brachiopods. *J. Paleontol.*, 48, 674–696.

Conrad, T. A., 1839, Descriptions of new species of organic remains. Second annual report on the Palaeontological Department of the Survey. *Ann. Rep., New York Geol. Surv.*, 3, 57–66.

Cooper, G. A. and Dutro, J. T., 1982, Devonian brachiopods of New Mexico. *Bull. Am. Paleontol.*, 82–83, 1–215.

Ehlers, G. M. and Wright, J. D., 1955, The type species of *Spinoercytra* Fredericks and new species of the brachiopod genus from southwestern Ontario. *Condr. Mus. Paleontol., Univ. Michigan*, 13, 1–33.

Fredericks, G. N., 1916, Paleontological notes. 2. On some Upper Paleozoic Brachiopoda of Eurasia. *Com. Géol. Mém.*, N. S., 156, 1–87.

Hirata, M., 1966a, On the Upper Devonian Ohira Formation in the Outer Zone of Shikoku, Japan. *J. Soc. Earthscientist*, *Amateurs Japan (Chigaku Kenkyu)*, 17, 102–105.

Hirata, M., 1966b, Geology of the Yokokurayama district, Kochi Prefecture. *J. Soc. Earthscientist, Amateurs Japan (Chigaku Kenkyu)*, 17, 258–273.

Hoshizumi, H., Saito, M., Mizuno, K., Miyazaki, K., Toshimitsu, S. and Hoshizumi, H., 2015, *Map of Japan 1:200,000, Oita (2nd Ed.)*. Geol. Surv. Japan, AIST, 218 p.

Ivanova, E. A., 1959, On the systematics and evolution of the spiriferids (Brachiopoda). *Paleontol. Zh.*, 4, 47–63.

Ivanova, E. A., 1962, Ecology and evolution of Silurian and Devonian brachiopods from the Kuznetsk, Minusinsk and Tuvisn basins. *Tr. Paleontol. Inst., Akad. Nauk SSSR*, 88, 1–150.

Ivanova, E. A., 1972, Main features of spiriferid evolution (Brachiopoda). *Paleontol. Zh.*, 3, 28–42.

Kindle, E. M., 1909, The Devonian fauna of the Ouray Limestone. *U. S. Geol. Surv. Bull.*, 391, 1–60.

Minato, M., 1952, A further note on the Lower Carboniferous fossils of the Kitakami Montainland, northeast Japan. *J. Fac. Sci., Hokkaido Univ. Ser.* 4, 8, 136–174.

Minato, M., Hunahashi, M., Watanabe, J. and Kato, M., 1979, *Variscan Geohistory of Northern Japan: The Avean Orogeny*. Tokai Univ. Press, Tokyo, 427 p.

Miyamoto, T. and Tanimoto, Y., 1993, Late Pennsylvanian olistostrome Kamoshishigawa Formation in the Chichibui Belt of South Kyushu, Southwest Japan. *NOM, Spec. Vol.*, 9, 19–33.

Noda, M., 1934, Geological research in the region around Nagasaki, in the western part of the Kitakami Mountains. *J. Geol. Soc. Japan*, 41, 431–456.

Noda, M., 1961, Geology of the Mikuni-toge district, Oita Prefecture, Japan, with special reference to the Gotlandian deposit. *Rep. Earth Sci., Dept. Gen. Educ., Kyushu Univ.*, 7, 1–9.

Okami, K., Ehiro, M., Kuriyagawa, H. and Asanuma, A., 1987, *Leptophloeum* bearing formation in the “Hayachine Tectonic Belt”, Kitakami Massif, Northeast Japan. *J. Geol. Soc. Japan*, 93, 321–327.

Saito, M., Miyazaki, K., Toshimitsu, S. and Hoshizumi, H., 2005, *Geology of the Tomochi District. Quadrangle Series*, 1:50,000. Geol. Surv. Japan, AIST, 218 p.

Sakai, A., Teraoka, Y., Miyazaki, K., Hoshizumi, H. and Saka maki, Y., 1993, *Geology of the Mikamachi District, with Geological Sheet Map at 1:50,000*. Geol. Surv. Japan, 115 p.

Sato, T., 1956, On the Tateishi Formation and its Carboniferous coral fauna, in the northeastern part of the Abukuma Massif, Japan. *Sci. Rep., Tokyo Kyotoku Daigaku*, Sec. C, 2, 235–261.

Sato, Y., Aso, T. and Sugiyama, T., 2018, Lithostratigraphy and biostratigraphy on a limestone with basal elastic rocks found in the Takaya district, Mie-machi, Bungo-ehno City, Oita Prefecture. *Annu. Rep. Geol. Soc. Oita*, 24, 37–67.

Stainbrook, M. A., 1947, Brachiopods of the Percha Shale of New Mexico and Arizona. *J. Paleontol.*, 21, 297–328.

Tachibana, K., 1964, Upper Devonian and lowest Carboniferous formations in the vicinity of Minamiwai, Higashiya mamachi, Iwate Prefecture, Pt. 1. Study on the Devonian–Carboniferous boundary in the southwestern part of the Kitakami Mountainland. 1. *Bull. Fac. Lib. Arts, Nagasaki Univ.*, 4, 31–43.

Tachibana, K., 1981, Some species of late Upper Devonian and lowest Carboniferous brachiopods from the Higashiya ma-machi district, Iwate Prefecture, North Japan. *Annu. Rep., Fac. Educ., Iwate Univ.*, 41, 61–75.

Tanimoto, Y. and Miyamoto, T., 1986, The so-called Yuzuruha Formation distributed in the Yabeko-cho and Seiwa-mura, Kama misashiki-gun, Kumamoto Prefecture, Kyushu. 93rd Annu. Meet. Geol. Soc. Japan, Abst., 247.

Tazawa, J., 2000, The Palaeozoic of the Hida Gaigen, South Kitakami and Kurosegawa belts. *Mem. Geol. Soc. Japan*, 56, 39–52.

Tazawa, J., 2018, Late Devonian brachiopods from Choanji, South Kitakami Belt, Japan, and their stratigraphic significance. *Paleontol. Res.*, 22, 129–144.

Tazawa, J. and Niikawa, I., 2018, *Desquamatia (Seratrypa)* from the Upper Devonian Choanji Formation in the South Kitakami Belt, Japan, and its stratigraphical significance. *J. Geol. Soc. Japan*, 124, 111–116.

Tazawa, J., Yang, W.-P. and Miyake, Y., 2000, *Cyrtospirifer* and *Leptophloeum* from the Devonian Rosse Formation, Hida Gaigen Belt, central Japan. *J. Geol. Soc. Japan*, 106, 727–735.

Ternier, H. and Ternier, G., 1949, Essai sur l’evolution des spiriferides. *Div. Min. Géol., Serv. Géol., Notes Mém.*, 74B, 85–112.

Waagen, W., 1883, Salt Range fossils, 1. *Productus-Limestone fossils: Brachiopoda*. *Palaeontol. Indica*, Ser. 13, 1, 391–546.

Yanagida, J., Tanimoto, Y. and Miyamoto, T., 1987, Late Devonian brachiopods from the so-called Yuzuruha Formation,
Yabe-machi, Kumamoto Prefecture. *Proc. Nishinihon Branch, Geol. Soc. Japan*, 87, 15.

Yoshikura, S., Hada, S. and Isozaki, Y., 1990, Kurosegawa Terrane. *In Ichikawa, K., Mizutani, S., Hara, I., Hada, S. and Yao, A., eds., Pre-Cretaceous Terranes of Japan, Publication of IGCP Project No. 24: Pre-Jurassic evolution of eastern Asia, Nippon Insatsu Shuppan, Osaka, 185–201.*

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