Early Carboniferous (Visean) brachiopods from the Taishaku Limestone in the Wada area, Hiroshima Prefecture, southwest Japan

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Abstract

An Early Carboniferous brachiopod fauna consisting of three species, *Dictyoclostus* sp. (Productidina), *Finospirifer* sp. (Spiriferidina) and *Syringothyris* sp. (Spiriferinidina), is described from a tuffaceous limestone in the upper part of the Dangyokei Formation (the lowest formation of the Taishaku Limestone) in the Wada area, Jinsekikogen-cho, Jinseki-gun, Hiroshima Prefecture, southwest Japan. The Wada fauna is assigned a (probably late) Visean age. This is the first report of Early Carboniferous brachiopods from the Taishaku Limestone.

Key words: brachiopod, Dangyokei Formation, Early Carboniferous, Taishaku Limestone, Visean, Wada area.

Introduction

The Taishaku Limestone, distributed on the Taishaku Plateau, northeastern Hiroshima Prefecture, southwest Japan, is one of the Carboniferous–Permian limestone–basalt blocks in a Permian accretionary complex of the Akiyoshi Terrane (Kanmera et al., 1990). The limestone is stratigraphically subdivided into three formations (in ascending order): the Dangyokei Formation, the Eimyoji Formation and the Uyamano Formation. According to Hase et al. (1974), the Dangyokei Formation (150 m thick) consists of Lower Carboniferous basaltic rocks with thin limestone layers, the Eimyoji Formation (150 m thick) consists of Lower–Upper Carboniferous limestone, and the Uyamano Formation (400–500 m thick)

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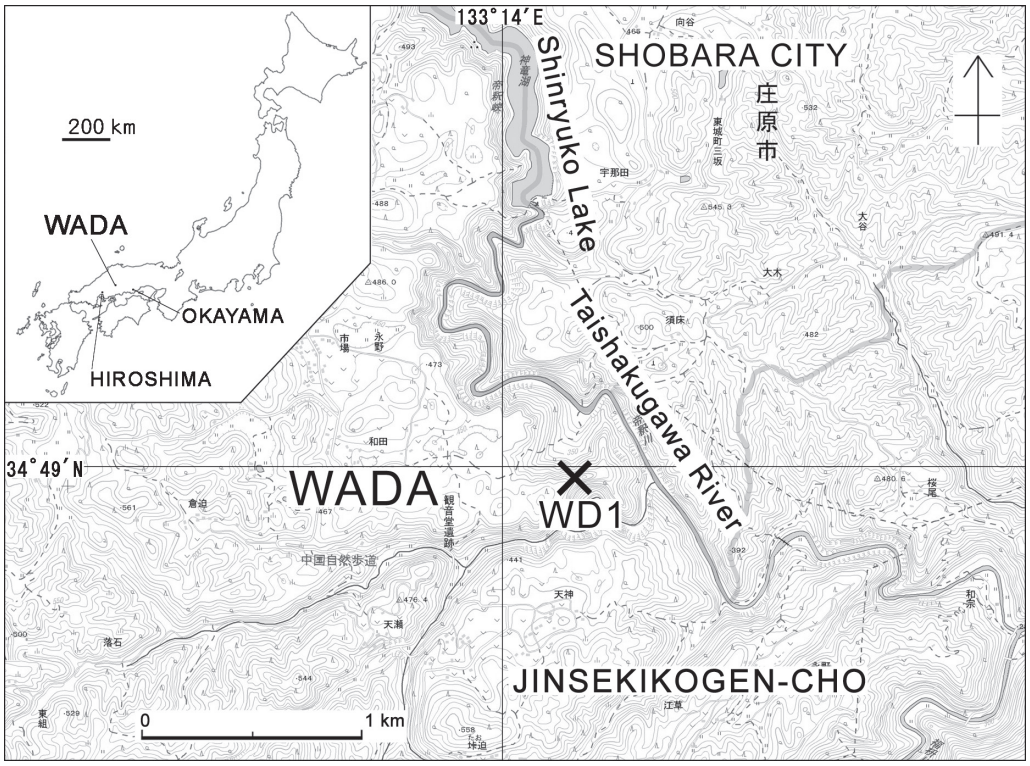

Fig. 1. Map showing the fossil locality (WD1) in the Wada area, using the topographic map "Fukunaga" scale 1:25,000, published by the Geospatial Information Authority of Japan.

consists of lower–middle Permian limestone.

The palaeontology of the Taishaku Limestone has been investigated in numerous studies, starting with the work of Yoshino (1937), and also including studies by Hanzawa (1941), Minato (1951, 1955), Yokoyama (1957, 1960), Endo (1957), Konishi (1960) and Akagi (1971). However, the lithostratigraphy and biostratigraphy of the limestone are relatively poorly documented, as compared with similar studies on the Akiyoshi and Omi limestones of the Akiyoshi Terrane. Recently, Ehiro et al. (2013) described the ammonoid *Dombarites taishakuensis* Ehiro from the upper part of the Dangyokei Formation in the Wada area, and based on this occurrence assigned the upper part of the formation to the Serpukhovian.

The present study describes several species of small brachiopod fauna from the Dangyokei Formation (newly named as the Wada fauna), and discusses the age of the fauna. The brachiopod specimens were collected by the second author (I. Nishikawa) from purple to greenish-grey tuffaceous limestone in the upper part of the Dangyokei Formation at locality WD1 (34°48′58″N, 133°14′14″E) in the Wada area, Jinsekikogen-cho, Jinseki-gun, Hiroshima Prefecture, southwest Japan (Fig. 1), which is the same locality as that examined by Ehiro et al. (2013). The specimens are registered and housed in the Fossa Magna

Museum in Itoigawa, Niigata Prefecture, central Japan, with the prefix FMM. This is the first report of Early Carboniferous brachiopods from the Taishaku Limestone.

Age of the Wada fauna

The Wada fauna comprises the following three species: *Dictyoclostus* sp., *Finospirifer* sp. and *Syringothyris* sp. Among these, *Dictyoclostus* sp. resembles *Dictyoclostus* sp. reported by Hase and Yokoyama (1975) from the *Eostaffella–Millerella* Zone (upper Visean) of the Hina Limestone, Okayama Prefecture, southwest Japan. *Finospirifer* sp. may be a new species, although the species somewhat resembles *Finospirifer shaoyangensis* (Ozaki, 1939), described by Ozaki (1939) from the upper Tournaisian of Hunan, central-southern China. *Syringothyris* sp. resembles *Syringothyris* cf. *cuspidata* (Martin), described by Ibaraki et al. (2014) from the *Eostaffella–Millerella* Zone (upper Visean) of the Koyama Limestone, Okayama Prefecture, southwest Japan. The occurrence of *Dictyoclostus* sp. and *Syringothyris* sp. suggests the Wada fauna is of Visean age, probably late Visean.

Our conclusion regarding the age of the newly described fauna is largely in agreement with previous studies on the age of the upper part of the Dangyokei Formation. Okimura (1966) and Sada (1975) considered the age to be late Visean–Serpukhovian, based on smaller foraminifers and fusulinids, and Ehiro et al. (2013) considered the age to be early Serpukhovian, based on the presence of the ammonid species *Dombarites taishakuensis*. Further investigations of the fossil fauna of the Dangyokei Formation are needed to confirm the age and composition of the faunas in the formation.

Systematic descriptions

Order Productida Sarytcheva and Sokolskaya, 1959
Suborder Productidina Waagen, 1883
Superfamily Productoidea Gray, 1840
Family Dictyoclostidae Stehli, 1954
Subfamily Dictyoclostinae Stehli, 1954
Genus *Dictyoclostus* Muir-Wood, 1930

Type species.—*Anomites semireticulatus* Martin, 1809.

Dictyoclostus sp.
Figs. 2.1–2.3

Material.—Four ventral valves, FMM5273–5275.

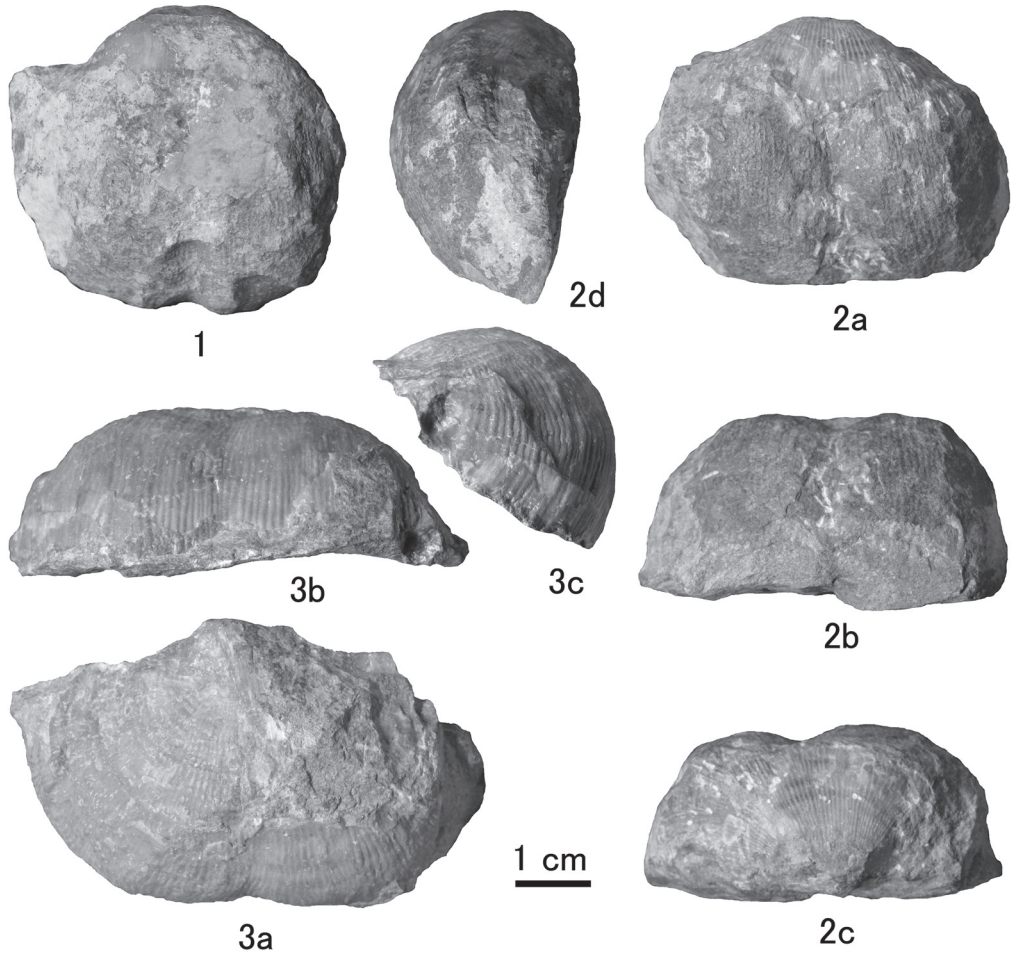

Fig. 2. *Dictyoclostus* sp.; 1, ventral valve, FMM5273; 2a, 2b, 2c, 2d, ventral, anterior, posterior and lateral views of ventral valve, FMM5274; 3a, 3b, 3c, ventral, anterior and lateral views of ventral valve, FMM5276.

Description.—Shell medium in size for genus, transversely rounded-quadrate in outline, with greatest width at hinge; length about 40 mm, width about 56 mm in the best preserved ventral valve specimen (FMM5273). Ventral valve strongly and unevenly convex in lateral profile, most convex at umbonal region, roundly geniculated, and followed by a long trail; umbo massive; ears small, slightly convex; sulcus narrow and shallow, originating at about mid of visceral disc; lateral slopes steep. External surface of ventral valve ornamented with numerous fine costae and rugae on visceral disc, and costae only on trail; numbering 8–9 costae and 3 rugae in 5 mm at about midlength; spines or spine bases absent.

Remarks.—The Wada species resembles *Dictyoclostus* sp., figured by Hase and Yokoyama (1975, pl. 18, fig. 1), from the *Eostaffella–Millerella* Zone (upper Visean) of the Hina Limestone in the Hina area, Okayama Prefecture, southwest Japan, in size, shape and

external ornament of the ventral valve. But specific identification is difficult owing to the lack of a description of the Hina specimens.

The type species, *Dictyoclostus semireticulatus* (Martin, 1809), redescribed and refigured by Muir-Wood (1928, p. 93, pl. 4, figs. 1, 2; text-fig. 19), from the Visean of England and Ireland, is clearly distinguished from the present species by its much larger size, larger ears, and coarser costae on the ventral valve.

Dictyoclostus multispiniferus (Muir-Wood, 1928, p. 121, pl. 7, fig. 6; pl. 8, figs. 1, 2; text-fig. 23), from the Tournaisian and Visean of England and Ireland, is similar to the Wada species in size and shape of the shell, but differs in having coarser costae and numerous spine bases over the visceral disc of the ventral valve.

Order Spiriferida Waagen, 1883
Suborder Spiriferidina Waagen, 1883
Superfamily Spifireroidea King, 1846
Family Spiriferidae King, 1846
Subfamily Prospirinae Carter, 1974
Genus *Finospirifer* Yin, 1981

Type species.—*Finospirifer taoyangensis* Yin, 1981.

Finospirifer sp.
Fig. 3.3

Material.—One specimen: a conjoined valve, FMM5280.

Description.—Shell small in size for genus, transversely subtrianglar in outline, with greatest width at slightly anterior to hinge line; length 22 mm, width 30 mm. Ventral valve moderately and unevenly convex in lateral profile, most convex at umbonal region; umbo small; interarea low and slightly shorter than hinge line; cardinal extremities produced; sulcus narrow and deep, with a strong median costa. Dorsal valve with a narrow and high fold, developed in anterior margin. External surface of both ventral and dorsal valves ornamented with numerous simple strong costae and numerous fine growth lines; costae numbering 7–8 in each lateral flank of ventral valve.

Remarks.—This specimen is safely assigned to the genus *Finospirifer*, based on its strongly transverse, alate outline, low interarea, and sulcus with a disproportionately strong median costa. The Wada species, which may be a new species, most closely resembles *Finospirifer shaoyangensis* (Ozaki, 1939), originally described as *Spirifer shaoyangensis* by Ozaki (1939, p. 257, pl. 41, fig. 1), from the upper Tournaisian of Hunan, central-southern China in general shape, but differs from the later in its smaller size and more acute cardinal

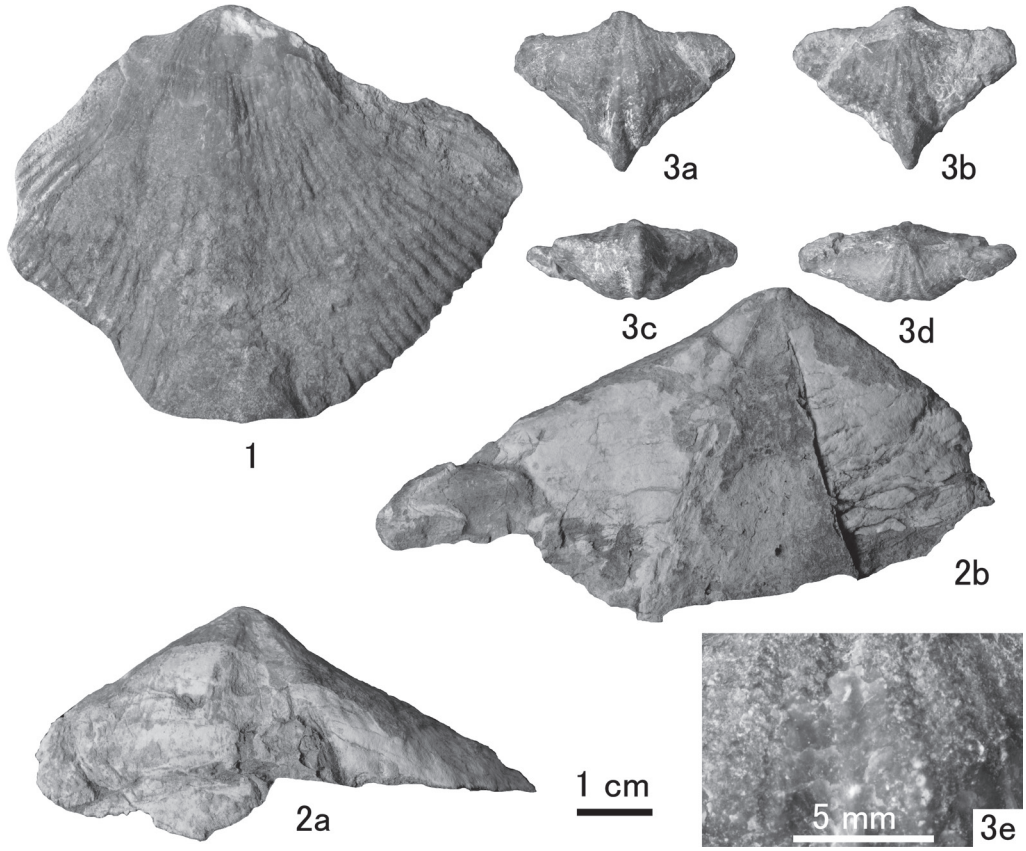

Fig. 3. 1, 2, *Syringothyris* sp.; 1, dorsal valve, FMM5277; 2a, 2b, ventral and posterior views of ventral valve, FMM5278; **3,** *Finospirifer* sp.; 3a, 3b, 3c, 3d, 3e, ventral, dorsal, anterior, posterior views and a part of enlarged ventral view of conjoined valves, FMM5280.

extremities. The type species, *Finospirifer taoyangensis* Yin, 1981, from the Mengongao Formation (upper Tournaisian) of Hunan, central-southern China, differs from the present species in having finer and more numerous costae and a higher interarea.

Order Spiriferinida Ivanova, 1972
Suborder Spiriferinidina Ivanova, 1972
Superfamily Syringothyridoidea Fredericks, 1926
Family Syringothyrididae Fredericks, 1926
Subfamily Syringothyridinae Fredericks, 1926
Genus *Syringothyris* Winchell, 1863

Type species.—*Syringothyris typa* Winchell, 1863.

Syringothyris sp.
Figs. 3.1, 3.2

Material.—Three specimens: (1) a ventral valve, FMM5277; (2) two dorsal valves, FMM5278, 5279.

Description.—Shell large in size for genus, transversely subelliptical in outline; length about 58 mm, width more than 73 mm in the best preserved dorsal valve specimen, FMM5277. Ventral valve subpyramidal; umbo small; cardinal extremities are not observable because of its ill preservation; interarea high, about 40 mm height in the single ventral valve specimen (FMM 5279), nearly flat, with triangular delthyrium, delthyrial angle 40°. External surface of dorsal valve ornamented with numerous simple coarse costae; numbering 5–6 in 10 mm at about midlength.

Remarks.—The materials from Wada are safely assigned to the genus *Syringothyris*, based on the large transverse shell, high and nearly flat ventral interarea and in having numerous simple coarse costae on lateral flanks of the dorsal valve. The Wada species somewhat resembles *Syringothyris* cf. *cuspidata* (Martin), described by Ibaraki et al. (2014, p. 74, figs. 4.4, 4.5), from the lower part of the Koyama Limestone (upper Visean), Oga, Okayama Prefecture, southwest Japan in having high ventral interarea and a number of costae on the dorsal valve. But accurate comparisons are difficult due to the poor preservation of the Wada specimens.

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