A spiriferid brachiopod species, *Purdonella tschernyschewiformis* (Ozaki, 1931), from the Upper Carboniferous of Fukuji, central Japan

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Abstract

A spiriferid brachiopod species, *Purdonella tschernyschewiformis* (Ozaki, 1931), is described from an Upper Carboniferous (Bashkirian) limestone of the Ichinotani Formation in the Fukuji area, Hida Gaien Belt, central Japan. This species is known from the Upper Carboniferous (Bashkirian-Moscovian) of Liaoning, Northeast China and Xinjiang, Northwest China. The distribution of the genus *Purdonella* is restricted to the Upper Carboniferous-Lower Permian of the Boreal region, so far as known. Therefore, the occurrence of *P. tschernyschewiformis* within Bashkirian limestone at Fukuji suggests that the Hida Gaien region, including the Fukuji area, was part of a continental shelf bordering the eastern margin of North China (Sino-Korea) during the Late Carboniferous.

Key words: Boreal, brachiopod, Fukuji, Hida Gaien Belt, *Purdonella tschernyschewiformis*, Upper Carboniferous.

Introduction

The purpose of the present paper is to describe a spiriferid brachiopod species, *Purdonella tschernyschewiformis* (Ozaki, 1931), from an Upper Carboniferous (Bashkirian) limestone of the Ichinotani Formation at Fukuji, Takayama City, Gifu Prefecture, viz., Hida Gaien Belt, central Japan, and to discuss the palaeogeography of the Fukuji area based on the

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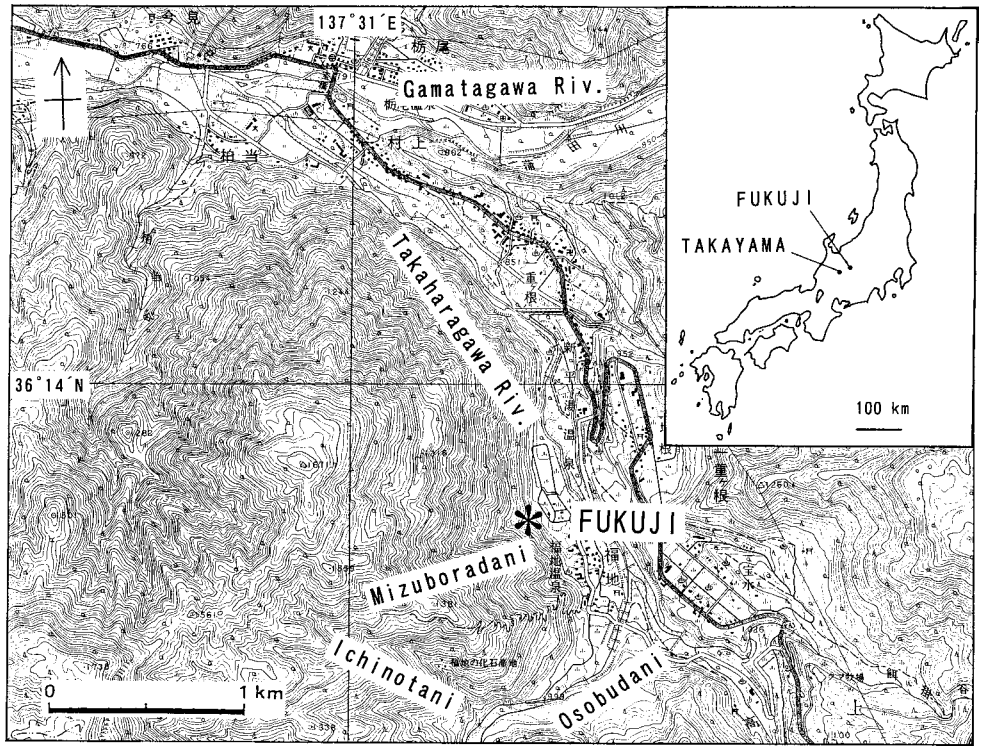

Fig. 1. Index map showing the sampling locality (asterisk) of the fossil-bearing limestone float in the Mizuboradani Valley, Fukuji area (using the topographical map of "Yakedake" scale 1:25,000 published by the Geographical Survey Institute of Japan) (after Tazawa et al., 2010).

palaeobiogeographical data obtained from this species and the genus *Purdonella*. The material was found by Yukio Miyake from a limestone float in the Mizuboradani Valley, a tributary of the Takaharagawa River (Fig. 1). The age of the limestone float is assigned to the Bashkirian based on the presence of the fusulinids *Eostaffella*? sp., *Millerella* aff. *marblensis* Thompson, and *Ozawainella* sp. (Tazawa et al., 2010).

The brachiopod specimens described in this paper are registered and housed in the Department of Geology, Faculty of Science, Niigata University, Niigata, Japan.

Distribution of *Purdonella*

The genus *Purdonella* was proposed by Reed (1944, p. 218) with *Spirifer nikitini* Tschernyschew, 1902 as the type species. The genus is characterized by its short hinge line, rounded ears, high ventral interarea, deep sulcus and high fold, external ornamentation of numerous fine costae on both valves, and long converging dental plates in the ventral valve. The following 22 species of this genus have been described from the Upper Carboniferous

(Bashkirian) to the Lower Permian (Kungurian) of North America, northern Russia, Uzbekistan (Fergana), North and Northeast China, central and southwest Japan, and Malaysia.

Purdonella nikitini (Tschernyschew, 1902): Upper Carboniferous (Moscovian) to Lower Permian (Artinskian). Southeast British Columbia, western Canada (Logan and McGugan, 1968); northern Yukon Territory, northern Canada (Shi and Waterhouse, 1996; Gorveatt and Nelson, 1975); Kolyma, Pai Khoi, Pechora Basin, Timan and the northern Urals, northern Russia (Tschernyschew, 1902; Stepanov, 1937; Zavodovsky and Stepanov, 1970; Kalashnikov, 1980, 1998); Bashkiria, western slope of the southern Urals (Kalashnikov, 1986); North Xinjiang, Northwest China (Zhang et al., 1983; Chen, 2004); Gansu, North China (Zhang et al., 1983); Junggar, western Inner Mongolia, North China (Zeng, 1990); and Liaoning, Northeast China (Hayasaka, 1922; Ozaki, 1931; Lee et al., 1980).

Purdonella nalivkini (Fredericks, 1924): Upper Carboniferous (Kasimovian-Gzhelian). Fergana, Uzbekistan (Fredericks, 1924).

Purdonella yavorskii (Fredericks, 1924): Upper Carboniferous (Moscovian-Gzhelian). Fergana, Uzbekistan (Fredericks, 1924); Shandong, East China (Ozaki, 1931; Wang et al., 1982).

Purdonella sp. cf. *P. nikitini* (Tschernyschew, 1902) of Ozaki (1931): Upper Carboniferous (Moscovian-Kasimovian). Shandong, East China and Liaoning, Northeast China (Ozaki, 1931).

Purdonella tschernyschewi (Ozaki, 1931): Upper Carboniferous (Kasimovian)-Lower Permian (Asselian). Northern Urals (Tschernyschew, 1902); North Xinjiang, North China (Wang, 1995; Wang and Yang, 1998); Shanxi, North China (Ozaki, 1931).

Purdonella nikitiniformis (Ozaki, 1931): Upper Carboniferous (Moskovian-Gzhelian). Moscow Basin (Prokofiev, 1975); Liaoning, Northeast China (Ozaki, 1931; Lee et al., 1980).

Purdonella tschernyschewiformis (Ozaki, 1931): Upper Carboniferous (Bashkirian-Moscovian). North Xinjiang, Northwest China (Wang and Yang, 1998); Liaoning, Northeast China (Ozaki, 1931; Wang, 1955; Wang et al., 1964; Lee et al., 1980); Fukuji, Hida Gaien Belt, central Japan (this study).

Purdonella borealis (Fredericks, 1936): Lower Permian (Kungurian). Novaya Zemlya, northern Russia (Fredericks in Lazurkin and Freyberg, 1936).

Purdonella pseudonikitini (Ustritsky, 1960): Upper Carboniferous (Kasimovian) to Lower Permian (Asselian). South Xinjiang, Northwest China (Ustritsky, 1960); Xiujimqinqi, eastern Inner Mongolia, North China (Lee and Gu, 1976); Shanxi, North China (He et al., 1995; Fan and He, 1999).

Purdonella markovskii Zavodowsky, 1968: Lower Permian (Asselian-Sakmarian). Kolyma, northern Russia (Zavodowsky in Markovsky, 1968; Zavodowsky and Stepanov, 1970).

Purdonella edelchteini Zavodowsky, 1970: Lower Permian (Asselian). Kolyma, northern Russia (Zavodowsky and Stepanov, 1970).

Purdonella sp. cf. *P. nikitini* (Tschernyschew, 1902) of Bamber and Waterhouse (1971): Lower Permian (Sakmarian). Northern Yukon Territory, northern Canada (Bamber and

Table 1. Stratigraphical and geographical distributions of the species assigned to the genus *Purdonella*. References to the numbers appended to regions are in Fig. 2 (after Tazawa et al., 2010).

Species \ Stage & Region	Stage								Region																								
	Bashkirian	Moscovian	Kasimovian	Gzhelian	Asselian	Sakmarian	Artinskian	Kungurian	British Columbia (1)	Yukon Territory (2)	Kolyma (3)	Novaya Zemlya (4)	Pai Khoi (5)	Pechora Basin (6)	Timan (7)	N. Urals (8)	Bashkiria (9)	Moscow Basin (10)	S. Urals (11)	Fergana (12)	S. Xinjiang (13)	N. Xinjiang (14)	Gansu (15)	Junggar (16)	Xiujimqinqi (17)	Shanxi (18)	Shandong (19)	Liaoning (20)	Fukuji (21)	Kawai (22)	W. Malaysia (23)
Purdonella nikitini (Tschernyschew)									+	+	+		+	+	+	+	+					+	+	+				+				
Purdonella nalivkini (Fredericks)																				+												
Purdonella yavorskii (Fredericks)																				+							+					
Purdonella cf. *nikitini* of Ozaki (1931)																											+	+				
Purdonella tschernyschewi (Ozaki)																	+					+				+						
Purdonella nikitiniformis (Ozaki)																			+									+				
Purdonella tschernyschewiformis (Ozaki)																						+						+	+			
Purdonella borealis (Fredericks)												+																				
Purdonella pseudonikitini (Ustritsky)																					+				+	+						
Purdonella markovskii Zavodowsky											+																					
Purdonella edelchteini Zavodowsky											+																					
Purdonella cf. *nikitini* of Bamber & Waterhouse (1971)										+																						
Purdonella sp. of Bamber & Waterhouse (1971)										+																						
Purdonella aucta Einor																+																
Purdonella elongata Einor																+																
Purdonella praenikitini Kalashnikov												+																				
Purdonella sadai Yanagida & Nishikawa																															+	
Purdonella artuxensis Zhan & Wu																					+											
Purdonella minur Zeng																								+								
Purdonella sp. of Shi & Waterhouse (1991)																																+
Purdonella rhombiformis Fan & He																										+						
Purdonella kalashnikovi Poletaev																	+	+														

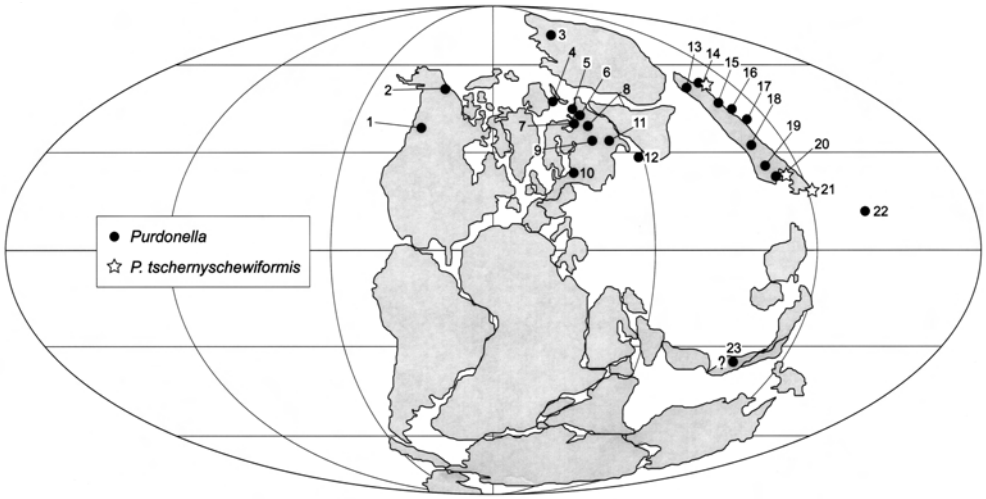

Fig. 2. Geographical distribution of *Purdonella tschernyschewiformis* (Ozaki) and the other species assigned to the genus *Purdonella* in the Late Carboniferous-Early Permian. 1: Southeast British Columbia, 2: Northern Yukon Territory, 3: Kolyma, 4: Novaya Zemlya, 5: Pai Khoi, 6: Pechora Basin, 7: Timan, 8: Northern Urals, 9: Bashkiria, 10: Moscow Basin, 11: Southern Urals, 12: Fergana, Uzbekistan, 13: South Xinjiang, NW China, 14: North Xinjiang, NW China, 15: Gansu, North China, 16: Junggar, Inner Mongolia, 17: Xiujimqinqi, Inner Mongolia, 18: Shanxi, North China, 19: Shandong, East China, 20: Liaoning, Northeast China, 21: Fukuji, central Japan, 22: Kawai, Southwest Japan, 23: West Malaysia (after Tazawa et al., 2010).

Waterhouse, 1971).

Purdonella sp. of Bamber and Waterhouse (1971): Upper Carboniferous (Gzhelian). Northern Yukon Territory, northern Canada (Bamber and Waterhouse, 1971).

Purdonella aucta Einor in Alexandrov and Einor, 1979: Upper Carboniferous (Kasimovian-Gzhelian). Bashkiria, western slope of the southern Urals (Alexandrov and Einor, 1979).

Purdonella elongata Einor in Alexandrov and Einor, 1979: Upper Carboniferous (Gzhelian). Bashkiria, western slope of the southern Urals (Alexandrov and Einor, 1979).

Purdonella praenikitini Kalashnikov, 1980: Upper Carboniferous (Bashkirian). Novaya Zemlya, northern Russia (Kalashnikov, 1980).

Purdonella sadai Yanagida and Nishikawa, 1984: Lower Permian (Asselian-Sakmarian). Kawai, Akiyoshi Belt, southwest Japan (Yanagida and Nishikawa, 1984).

Purdonella artuxensis Zhan and Wu, 1987: Upper Carboniferous (Moscovian) to Lower Permian (Asselian). South Xinjiang, Northwest China (Zhan and Wu, 1987; Chen and Shi, 2000).

Purdonella minur Zeng, 1990: Upper Carboniferous (Moscovian). Junggar, western Inner Mongolia, North China (Zeng, 1990).

Purdonella sp. of Shi and Waterhouse (1991): Lower Permian (Sakmarian). West Malaysia (Shi and Waterhouse, 1991).

Purdonella rhombiformis Fan and He, 1999: Upper Carboniferous (Kasimovian-Gzhelian). Shanxi, North China (Fan and He, 1999).

Purdonella kalashnikovi Poletaev, 2006: Upper Carboniferous (Moscovian-Kasimovian). Northern and southern Urals (Poletaev, 2006).

Late Carboniferous palaeogeography of the Fukuji area

The stratigraphical and geographical distributions of the genus *Purdonella* and the species *P. tschernyschewiformis* are summarized in Table 1 and Fig. 2.

Purdonella is a Boreal-type brachiopod of the Boreal Realm during the Late Carboniferous and Early Permian; *P. tschernyschewiformis* has been reported from the Upper Carboniferous (Bashkirian-Moscovian) of North Xinjiang, Northwest China and Liaoning, Northeast China. According to Yang (1994), North Xinjiang belongs to the Junggar-Xingan Province, and the Liaoning Province belongs to the North China-Qilian Province. Therefore, the occurrence of *P. tschernyschewiformis* from Fukuji indicates a provincial affinity between the Fukuji area and Northwest to Northeast China during the Late Carboniferous. Based on the above evidence, it is concluded that the Fukuji area was probably located upon the continental shelf along the eastern side of North China during the Late Carboniferous.

Kato (1990) and Igo and Adachi (2001) mentioned that corals from the Ichinotani Formation of Fukuji contain Boreal elements such as *Lytvophyllum* and *Koninckocarina,* thereby supporting the above conclusion.

Systematic descriptions

Order Spiriferida Waagen, 1883
Suborder Spiriferidina Waagen, 1883
Superfamily Spiriferacea King, 1846
Family Brachythyrididae Fredericks, 1924
Genus *Purdonella* Reed, 1944

Type species.—*Spirifer nikitini* Tschernyschew, 1902.

Purdonella tschernyschewiformis (Ozaki, 1931)
Figs. 3.1a-3.3

Spirifer (*Munella*) *tschernyschewiformis* Ozaki, 1931, p. 66, pl. 6, figs. 11-14; pl. 7, figs. 1-3.
Purdonella tschernyschewiformis (Ozaki): Wang, 1955, p. 143, pl. 80, figs. 9, 12, 15, 16; Wang and Yang, 1998, p. 121, pl. 20, figs. 3a, 3b; pl. 21, figs. 10a, 10b; Tazawa et al., 2010, figs. 3A-3F.

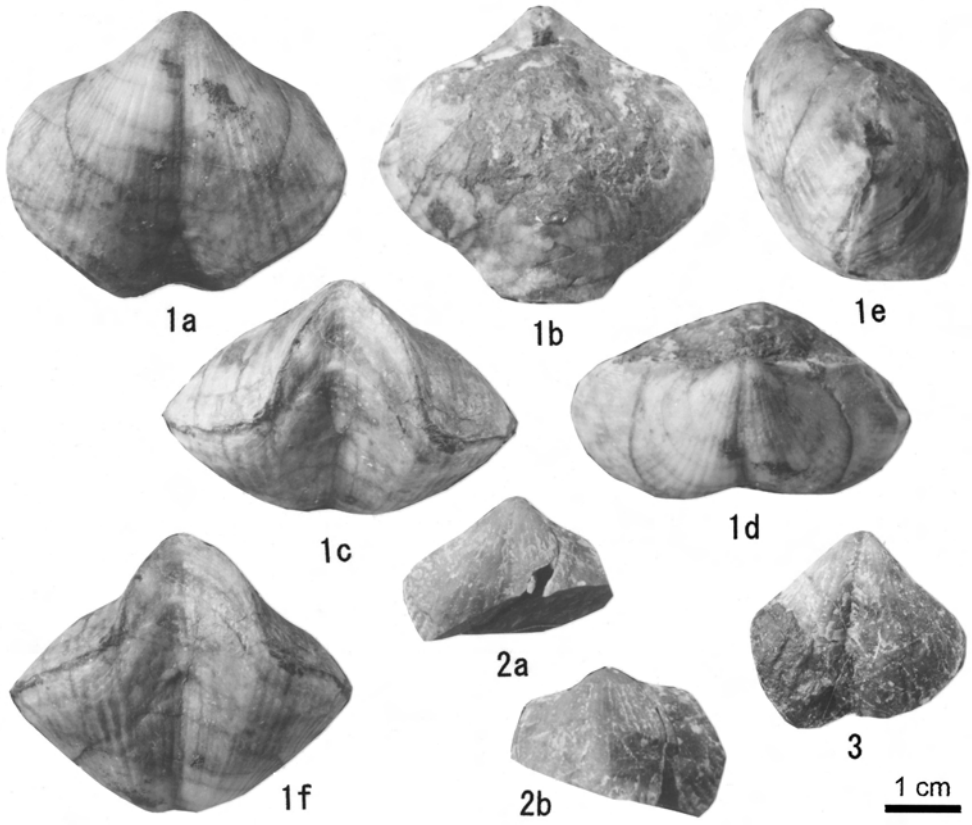

Fig. 3. *Purdonella tschernyschewiformis* (Ozaki, 1931) from the limestone float derived from the lower part of the Ichinotani Formation at the Mizuboradani Valley, Fukuji. 1a, 1b, 1c, 1d, 1e, 1f: ventral, dorsal, anterior, posterior, lateral, and oblique anterior views of conjoined valve, NU-B1193, 2a, 2b: ventral and dorsal views of conjoined valve, NU-B1194, 3: ventral view of ventral valve, NU-B1195.

Choristites tschernyschewiformis (Ozaki): Wang et al., 1964, p. 485, pl. 85, figs. 11-15; Lee and Su in Lee et al., 1980, p. 414, pl. 156, figs. 6, 15.

Material.—Four specimens: (1) two conjoined valves, NU-B1193, 1194; (2) two ventral valves, NU-B1195, 1196.

Description.—Shell medium size for genus, transversely subelliptical in outline, subequally biconvex, ventral valve more inflated than dorsal valve; hinge short; cardinal extremities rounded; anterior commissure uniplicate; greatest width at about midvalve; length 39 mm, width 46 mm in the best preserved specimen (NU-B1193); length 27 mm, width 30 mm in a ventral valve specimen (NU-B1195).

Ventral valve moderately convex in lateral profile, with maximum convexity at umbonal region; beak considerably incurved; interarea not sharply defined, triangular, high and concave, with an opened delthyrium; ears small and rounded; sulcus originating as a groove at beak, becoming broad and deep with slightly angular bottom towards anterior margin of valve, and followed by a long anterior prolongation; lateral slopes slightly and evenly convex; boundary between sulcus and lateral slopes being not clear. External surface of ventral valve ornamented with numerous low flattened costae; costae often bifurcating anteriorly and becoming fainter towards cardinal margin, numbering 13 in sulcus and 20-22 in each lateral slope. Dorsal valve less convex than the opposite valve; fold narrow and low in posterior region, becoming broad and high towards anterior margin of valve; lateral slopes gently and evenly convex. External ornament of dorsal valve same as the opposite valve, although they are poorly preserved and obscure in the present material.

Remarks.—The Fukuji specimens are referred to *Purdonella tschernyschewiformis* (Ozaki, 1931), originally described from the Upper Carboniferous Benxi Formation of Liaoning Province, Northeast China in size, shape and surface ornamentation of the shells, especially in having a prominent anterior prolongation of the ventral sulcus.

The type species, *Purdonella nikitini* (Tschernyschew, 1902, p. 154, 542, pl. 10, figs. 1, 2 only), from the Lower Permian (Asselian) of the northern Urals, is easily distinguished from *P. tschernyschewiformis* by its broader ventral sulcus with rounded bottom and less prominent anterior prolongation.

Purdonella sadai Yanagida and Nishikawa (1984, p. 188, pl. 19, figs. 1a-d), from the Lower Permian (Asselian and Sakmarian) of the Kawai Limestone in the Akiyoshi Belt, southwest Japan, differs from *P. tschernyschewiformis* in its larger size and less inflated ventral valve.

Purdonella tschernyschewi (Ozaki, 1931, p. 59, pl. 5, figs. 11a-c; pl. 6, figs. 2a, b), from the Upper Carboniferous (Kasimovian-Gzhelian) of Shanxi, North China, differs from the present species by its small size and longitudinally elongate outline of the shell.

Distribution.—Upper Carboniferous (Bashkirian-Moscovian): Northwest China (North Xinjiang), Northeast China (Liaoning), and central Japan (Hida Gaien Belt).

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