Systematics and palaeobiogeograpy of Permian brachiopods from Pliocene conglomerate of Hitachi, central Japan

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Abstract

This paper describes a Permian brachiopod fauna (Ishinazaka fauna) from shale and argillaceous limestone boulders in the basal conglomerate of the Pliocene Kume Formation of Hitachi, central Japan, and reexamines the age and palaeobiogeography of the fauna. The results, which are the same as our previous opinions, are as follows: 1) the Ishinazaka fauna, consisting of 17 species in 16 genera, resembles the middle Permian brachiopod fauna of the South Kitakami Belt in species composition, and indicates a middle Permian (Wordian) in age; 2) the Ishinazaka fauna is a mixed Boreal–Tethyan fauna in the Sino-Mongolian–Japanese Province; and 3) the Hitachi area was probably part of the continental shelf bordering the eastern margin of North China during the Wordian.

Key words: Ayukawa Formation, brachiopod, Hitachi Palaeozoic rocks, Ishinazaka fauna, Permian.

Introduction

The Hitachi Palaeozoic rocks (=Hitachi metamorphic rocks, Watanabe, 1920–1921; Kuroda, 1959; Tagiri, 1971), which contain the oldest rocks in Japan, are important for understanding the origin and geotectonic development of the Japanese Islands. Tagiri et al. (2011) proposed that the Hitachi Palaeozoic rocks originated from sediments of a Cambrian–Permian magmatic arc in the marginal area of North China (Sino-Korea), based on SHRIMP zircon dating and chemical analysis of the rocks. However, the origin of the Hitachi

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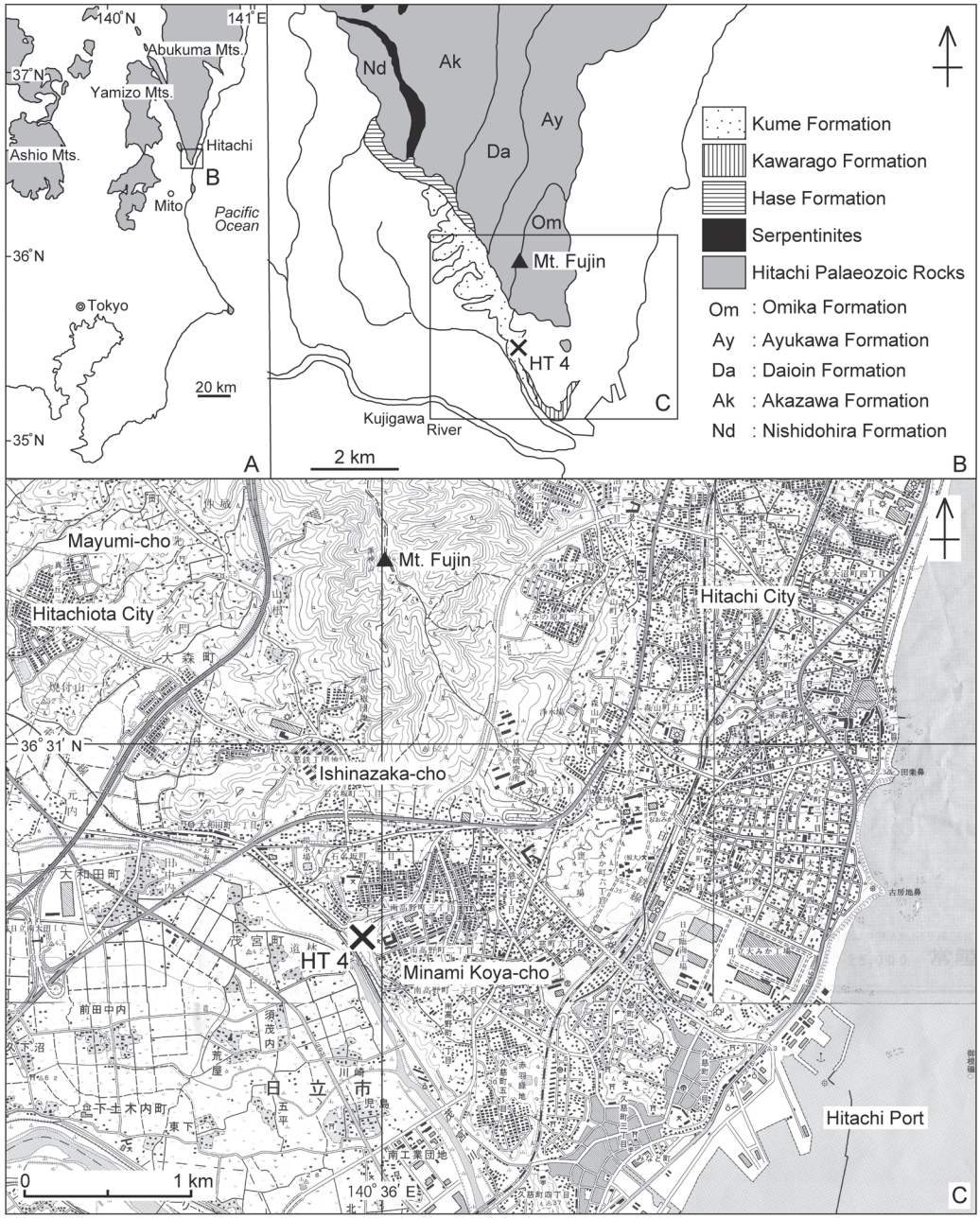


Fig. 1. Maps showing the location and geology of the Hitachi area, including the locations of fossil locality (HT4). (A) Distribution of pre-Neogene rocks in the eastern Kanto region (based on Takeuchi, 2008). (B) Geologic map of the Hitachi area (based on Tagiri et al., 2011). (C) Topographic map of the Hitachi area. Using 1 : 25,000 scale topographic maps of "Hitachi-Ota", "Hitachi-Kuji" and "Southern Hitachi", published by the Geospatial Information Authority of Japan (after Tazawa et al., 2014).

Palaeozoic rocks is still uncertain. For instance, Isozaki et al. (2010) assigned the Hitachi Palaeozoic rocks to the eastern extension of the Dabie–Sulu UHP metamorphic rocks in the collisional suture between North China and South China (Yangtze).

Recently, Tazawa et al. (2014) found a Permian brachiopod fauna (Ishinazaka fauna) from shale and argillaceous limestone boulders in the basal conglomerate of the Pliocene Kume Formation of Hitachi, central Japan, and stated as follows: 1) the fossil-bearing boulders are probably derived from the Permian Ayukawa Formation belonging to the Hitachi Palaeozoic rocks; 2) the Ishinazaka fauna, which contains 17 species in 16 genera, resembles the middle Permian brachiopod fauna of the South Kitakami Belt in terms of species composition, and indicates a middle Permian (Wordian) in age; 3) the Ishinazaka fauna is a mixed Boreal–Tethyan fauna in the Sino-Mongolian–Japanese Province; 4) the Ayukawa Formation is correlated with the lower to upper Permian of the southern Kitakami Mountains, northeastern Japan; and 5) the Hitachi area was probably located in the continental shelf bordered the eastern margin of North China during the Wordian.

This paper describes the Ishinazaka fauna on the material reported by Tazawa et al. (2014), and reexamines the age and biogeography of the fauna. The results are the same as those in Tazawa et al. (2014). The brachiopod specimens described below are registered with the prefix KFM and housed in the Kuzu Fossil Museum in Kuzu, Sano City, Tochigi Prefecture, Japan.

Geological setting

According to Tazawa et al. (2014), the brachiopod specimens of this study were collected from shale and argillaceous limestone boulders from the basal conglomerate of the Pliocence Kume Formation (Suzuki and Omori, 1953; Ozaki and Saito, 1954), which crops out at locality HT4 (36° 30′ 24″ N, 140° 35′ 53″ E). This locality is a cutting at the western border of the Sakamoto Elementary School, Minamikoya-cho, Hitachi City, Ibaraki Prefecture, central Japan (Figs. 1–3). The fossil-bearing boulders are black shale and dark grey argillaceous limestone of 0.3 to 1.5 m in diameter, and contain fossils of brachiopods, bryozoans, crinoids, fusulinids, bivalves, gastropods and trilobites. The Pliocence Kume Formation is distributed in the southwestern side of the Hitachi Palaeozoic rocks (Fig. 1B). Therefore, the fossil-bearing boulders are considered to have been derived from the Hitachi Palaeozoic rocks, probably from the Permian Ayukawa Formation, which consists of weakly metamorphosed or non-metamorphosed tuffaceous shale and sandstone, associated with minor limestone and conglomerate (Tagiri and Hiroi, 2008), and contains an early Permian fusulinid, "*Pseudofusulina*" *vulgaris,* reported by Sugiyama (1972) from a lenticular limestone block. The fossil-bearing shale and argillaceous limestone boulders are similar in lithology to those of the Ayukawa Formation, and also to those of the lower Kanokura Series (Minato et al.,

Fig. 2. Outcrop of the basal conglomerate of the Kume Formation in the fossil locality HT4, cutting at the western border of the Sakamoto Elementary School, Minamikoya-cho, Hitachi City, Ibaraki Prefecture.

1979), including the lower Kanokura Formation (Tazawa and Ibaraki, 2001) and lower Kamiyasse Formation (Misaki and Ehiro, 2004) of the South Kitakami Belt, northeastern Japan.

The Ishinazaka fauna

The brachiopods of the Ishinazaka fauna contains the following 17 species in 16 genera: *Isogramma heritschi* Nakamura, 1970, *Kitakamichonetes multicapillatus* Afanasjeva and Tazawa, 2007, *Transennatia gratiosa* (Waagen, 1884), *Spinomarginifera kueichowensis* Huang, 1932, *Bathymyonia ussurica* Kotlyar in Licharew and Kotlyar, 1978, *Bathymyonia neimongolica* (Wang and Zhang, 2003), *Urushtenoidea chaoi* (Jin, 1963), *Linoproductus* sp., *Permianella typica* He and Zhu, 1979, *Dicystoconcha lapparenti* Termier and Termier in Termier et al., 1974, *Schuchertella debaisiensis* Wang and Zhang, 2003, *Uncinunellina timorensis* (Beyrich, 1865), *Cleiothyridina* sp., *Martinia* sp., *Spiriferella* sp., *Spiriferellina fredericksi* Tazawa, 2014 and *Whitspakia* sp.

Representative specimens from the Ishinazaka fauna are shown in Figs. 6–8, and the

Fig. 3. Close view of the outcrop of the basal conglomerate of the Kume Formation in the fossil locality HT4.

geographical and stratigraphical distributions of the brachiopod species in the fauna, excluding 5 uncertain species, are summarized in Fig. 4.

Age and correlation

As shown in Fig. 4, *Isogramma heritschi* and *Spiriferellina fredericksi* are known from the Wordian; *Bathymyonia ussurica* and *B. neimongolica* are known from the Wordian–Capitanian; *Kitakamichonetes multicapillatus*, *Spinomarginifera kueichowensis* and *Permianella typica* are known from the Wordian–Wuchiapingian; and *Transennatia gratiosa* is known from the Wordian–Changhsingian. On the other hand, *Urushtenoidea chaoi* is known from the Roadian–Capitnian; *Dicystoconcha lapparenti* is known from the Kungurian–Wuchiapingian; and *Schuchertella debaisiensis* is known from the Kungurian–Wordian. *Uncinunellina timorensis* is a long-ranging species, known from the Asselian–Changhsingian.

In summary, the Ishinazaka fauna is identified as Wordian, which is younger than the early Permian age determined from the fusulinid species, "*Pseudofusulina*" *vulgaris* by Sugiyama (1972). The Ishinazaka fauna is determined to have been derived from the upper horizon rather than the fusulinid-bearing limestone bed of the Ayukawa Formation.

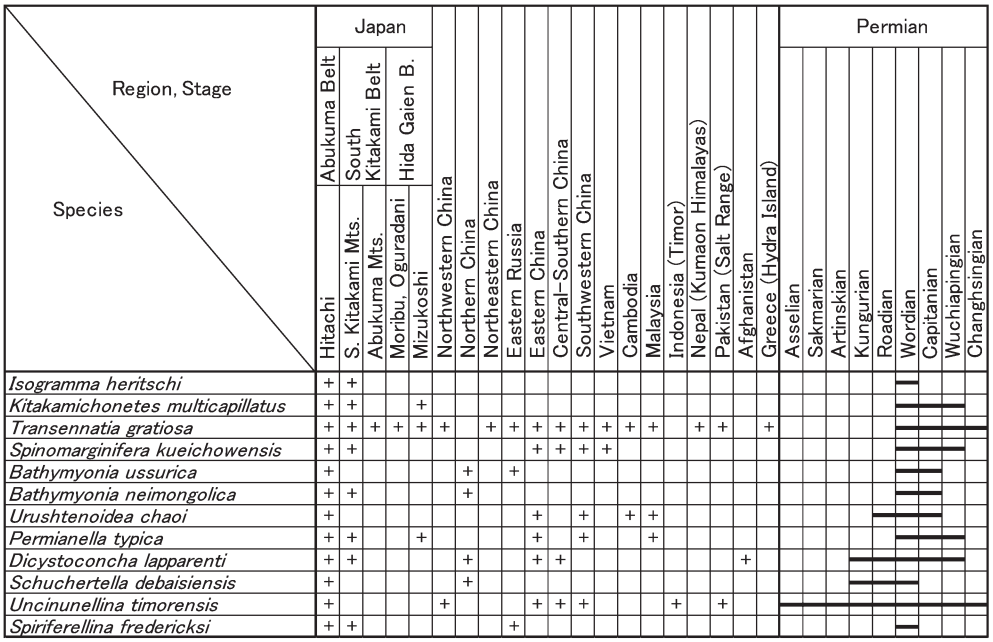


Fig. 4. Geographic and stratigraphic distributions of brachiopod species of the Ishinazaka fauna, excluding 5 uncertain species (modified from Tazawa et al., 2014).

Palaeobiogeography

Of the 17 species of the Ishinazaka fauna, 8 species also occur in the southern Kitakami Mountains (South Kitakami Belt), and 5 are known from eastern China and southwestern China, The Wordian fauna of the South Kitakami Belt shows particularly strong affinity with the Ishinazaka fauna. In palaeobiogeographical terms, *Bathymyonia* and *Spiriferella* are Boreal (antitropical)-type genera, whereas *Isogramma, Transennatia, Spinomarginifera, Permianella, Dicystoconcha* and *Urushtenoidea* are Tethyan (tropical)-type genera. Moreover, *Schuchertella debaisiensis* and *Spiriferellina fredericksi* are probably antitropical elements. Therefore, the Ishinazaka fauna is a mixed Boreal–Tethyan fauna dominated by Tethyan elements.

The present results indicate that during the middle Permian (Wordian) the Hitachi area was located slightly south to the South Kitakami area and also in a transitional zone between the Boreal and Tethyan realms, the Sino-Mongolian–Japanese Province (Shi and Tazawa, 2001, Shen et al., 2009) (Fig. 5). This province is equivalent to the Inner Mongolia–Japan Transitional Zone of Tazawa (1991, 2007), developed along the northern and eastern margins of North China. The Ayukawa Formation probably represents the southern extension of the Permian deposits of the South Kitakami Belt.

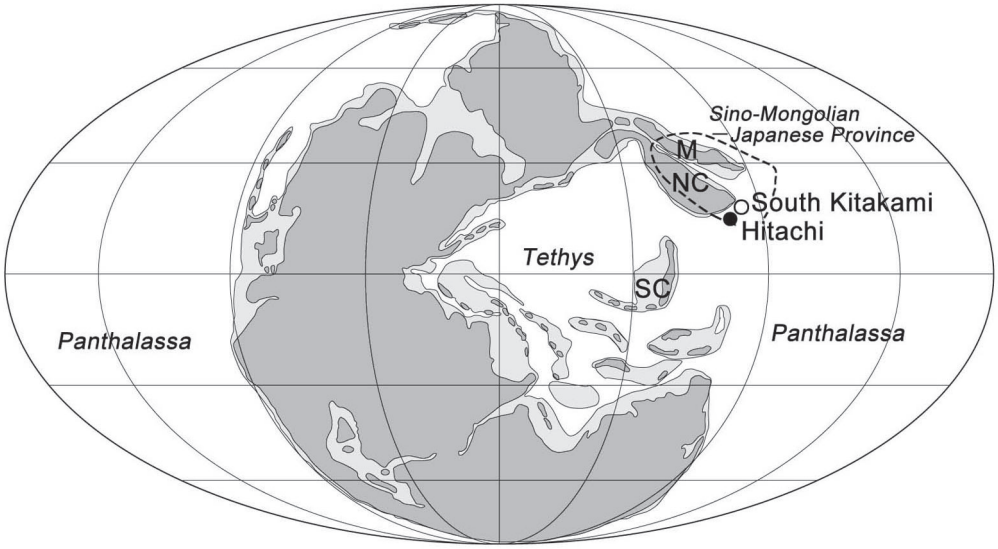


Fig. 5. Simplified middle Permian (Wordian) world map showing the Sino-Mongolian–Japanese Province and palaeoposition of both South Kitakami and Hitachi, using base map of Shen et al. (2009). M: Mongolia, NC: North China, SC: South China (after Tazawa et al., 2014).

Systematic descriptions

Order Dictyonellida Cooper, 1956
Superfamiy Eichwaldioidea Schuchert, 1893
Family Isogrammidae Schuchert, 1929
Genus *Isogramma* Meek and Worthen, 1870

Type species.—*Chonetes*? *millepunctatus* Meek and Worthen, 1870.

Isogramma heritschi Nakamura, 1970
Fig. 6.4

Isogramma heritschi Nakamura, 1970, p. 308, pl. 4, figs. 3–7; Minato et al., 1979, pl. 57, figs. 2–4, 6; Tazawa et al., 2014, p. 378, fig. 2.4.

Material.—One specimen, internal mould of a dorsal valve, KFM1872.

Remarks.—This specimen can be referred to *Isogramma heritschi* Nakamura, 1970, from the lower Kamiyasse Formation of the Kamiyasse–Imo area, South Kitakami Belt, northeastern Japan, by its medium-sized, flat, semicircular dorsal valve (length about 20 mm, width about 30 mm), and the external ornament consisting of numerous very fine concentric

growth lines and stronger concentric rugae; numbering 10–11 growth lines in 1 mm, 2–3 rugae in 5 mm at about midlength. *Isogramma paotechowensis* (Grabau and Chao in Chao, 1928, p. 33, pl. 1, fig. 27; pl. 4, figs. 1–5), from the Taiyuan Formation of Shanxi, northern China, is readily distinguished from *I. heritschi* by its larger dimensions and in having coarser growth lines in the dorsal valve.

Distribution.—Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt).

Order Productida Sarytcheva and Sokolskaya, 1959
Suborder Chonetidina Muir-Wood, 1955
Superfamily Chonetoidea Bronn, 1862
Family Rugosochonetidae Muir-Wood, 1962
Subfamily Chalimochonetinae Afanasjeva, 1988
Genus *Kitakamichonetes* Afanasjeva and Tazawa, 2007

Type species.—*Kitakamichonetes multicapillatus* Afanasjeva and Tazawa, 2007.

Kitakamichonetes multicapillatus Afanasjeva and Tazawa, 2007
Fig. 6.1

Kitakamichonetes multicapillatus Afanasjeva and Tazawa, 2007, p. 73, pl. 11, figs. 1–12; Tazawa, 2008b, p. 42, figs. 6.3, 6.4; Tazawa et al., 2014, p. 378, fig. 2.1.

Material.—One specimen, internal mould of a ventral valve, KFM1890.

Remarks.—The single imperfect specimen from Hitachi is referred to *Kitakamichonetes multicapillatus* Afanasjeva and Tazawa, 2007, from the lower Kamiyasse Formation of the Kamiyasse–Imo area, South Kitakami Belt, by its large chonetid shell (length more than 19 mm, width more than 22 mm), numerous costellae (numbering 9 in 2 mm near anterior valve margin) and long median septum in the ventral valve.

Distribution.—Wordian–Wuchiapingian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), central Japan (Hitachi) and southwestern Japan (Mizukoshi in central Kyushu, western extension of the Hida Gaien Belt).

Suborder Productidina Waagen, 1884
Superfamily Marginiferoidea Stehli, 1954
Family Marginiferidae Stehli, 1954
Subfamily Marginiferinae Stehli, 1954
Genus *Transennatia* Waterhouse, 1975

Type species.—*Productus gratiosus* Waagen, 1884.

Transennatia gratiosa (Waagen, 1884)
Figs. 6.2, 6.3

Productus gratiosus Waagen, 1884, p. 691, pl. 72, figs. 3–7; Diener, 1897, p. 23, pl. 3, figs. 3–7; Mansuy, 1913, p. 115, pl. 13, fig. 1; Colani, 1919, p. 10, pl. 1, fig. 2; Chao, 1927, p. 44, pl. 4, figs. 6–10; Chi-Thuan, 1962, p. 491, pl. 2, figs. 5–7.

Productus (*Dictyoclostus*) *gratiosus* Waagen: Huang, 1933, p. 88, pl. 11, fig. 14; Hayasaka, 1960, p. 49, pl. 1, fig. 8.

Marginifera gratiosa (Waagen): Reed, 1944, p. 98, pl. 19, figs. 6, 7.

Dictyoclostus gratiosus (Waagen): Zhang and Ching (Jin), 1961, p. 411, pl. 4, figs. 12–18; Wang et al., 1964, p. 291, pl. 45, figs. 14–19; Leman, 1994, pl. 1, figs. 11–13.

Gratiosina gratiosa (Waagen): Grant, 1976, pl. 33, figs. 19–26; Licharew and Kotlyar, 1978, pl. 12, figs. 5, 6; pl. 20, fig. 1; Minato et al., 1979, pl. 61, figs. 11–13.

Asioproductus gratiosus (Waagen): Yang et al., 1977, p. 350, pl. 140, fig. 5; Feng and Jiang, 1978, p. 254, pl. 90, figs. 1, 2; Tong, 1978, p. 228, pl. 80, fig. 7; Lee et al., 1980, p. 373, pl. 164, fig. 14; pl. 166, figs. 5, 6.

Gratiosina sp. Minato et al., 1979, pl. 61, fig. 14.

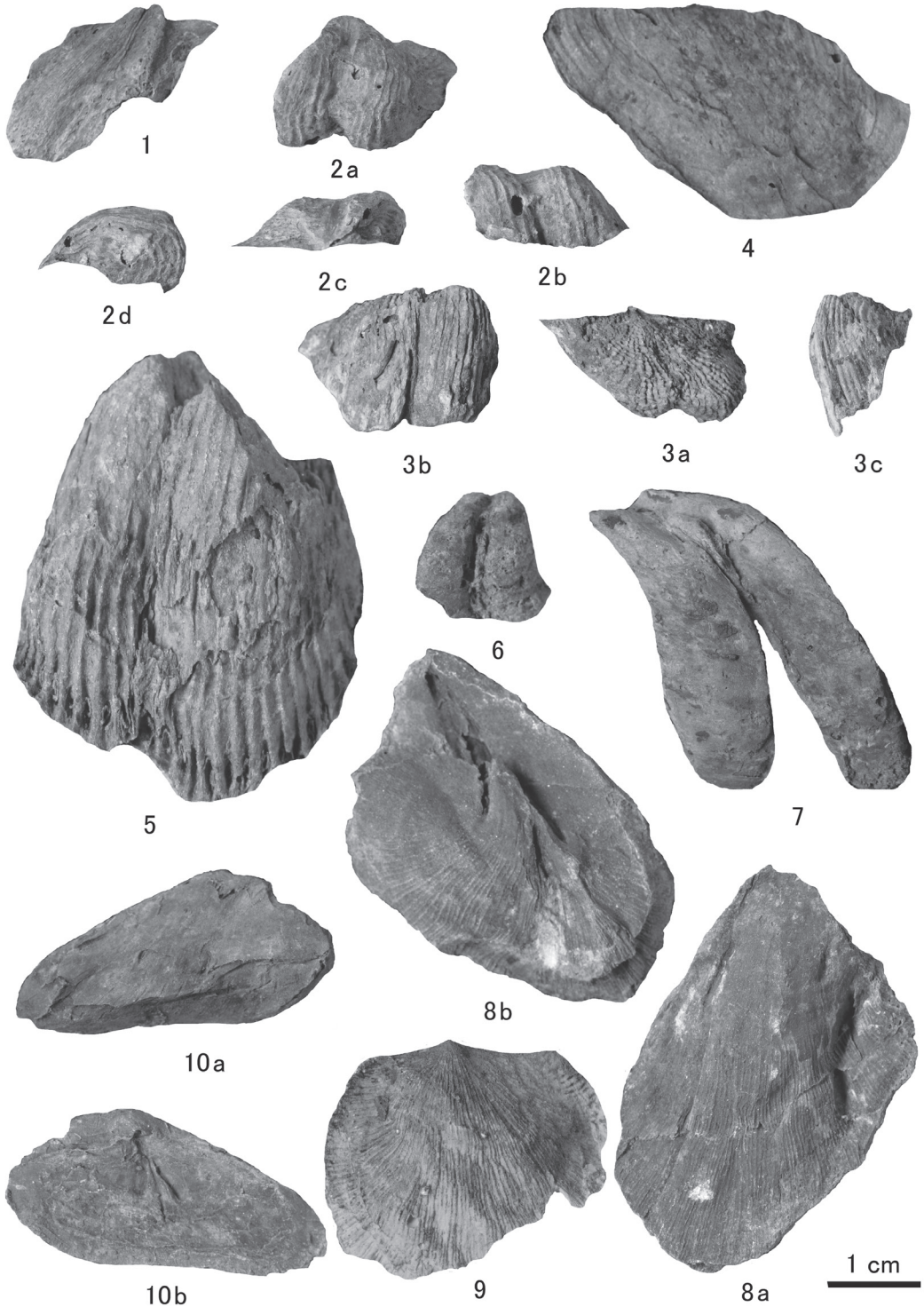
Dictyoclostus minor Lee and Gu in Lee et al., 1980, p. 372, pl. 166, figs. 1–4.

Transennatia gratiosus (Waagen): Wang et al., 1982, p. 214, pl. 92, figs. 6–8; pl. 102, figs. 4–9; Liu et al., 1982, p. 185, pl. 132, fig. 9; Ding and Qi, 1983, p. 280, pl. 95, fig. 14; Zeng et al., 1995, pl. 5, figs. 14, 15.

Transennatia gratiosa (Waagen): Yang, 1984, p. 219, pl. 33, fig. 7; Jin, 1985, pl. 4, figs. 33, 34, 45, 46; Tazawa and Matsumoto, 1998, p. 6, pl. 1, figs. 4–8; Tazawa et al., 2000, p. 7, pl. 1, figs. 3–5; Tazawa, 2001, p. 289, figs. 6.1–6.7; Tazawa and Ibaraki, 2001, p. 7, pl. 1, figs. 1–3; Shen et al., 2002, p. 676, figs. 4.27–4.31; Tazawa, 2002, fig. 10.2; Chen et al., 2005, p. 354, figs. 10E–10H, 11; Tazawa, 2008a, p. 26, fig. 4.1; Tazawa, 2008b, p. 43, figs. 6.6, 6.7; Shen and Zhang, 2008, figs. 4.20–4.22; Shen and Clapham, 2009, p. 718, pl. 1, figs. 13–22; Shen and Shi, 2009, p. 157, figs. 3K–3O; Tazawa et al., 2014, p. 378, figs. 2.2, 2.3.

Material.—Fifteen specimens: (1) internal moulds of three ventral valves, KFM1873–1875; (2) external moulds of twelve dorsal valves, KFM1876–1887.

Remarks.—These specimens are referred to *Transennatia gratiosa* (Waagen, 1884), originally described from the Wargal and Chhidru formations of the Salt Range, Pakistan, on the basis of their small size (length 13 mm, width 17 mm in the largest specimen, KFM1874), strongly convex ventral valve, strongly geniculated dorsal valve and sharply reticulate ornament on the visceral discs of both valves, although the Hitachi specimens are smaller in


1
2a
4
2d
2c
2b
3b
3a
3c
5
6
7
8b
10a
10b
9
8a
1 cm

size than the Salt Range specimens. *Dictyoclostus minor* Lee and Gu (in Lee et al., 1980), from the Miaoling Formation of Jilin, northeastern China, is probably a junior synonym of the present species.

Distribution.—Wordian–Changhsingian: northern China (Shaanxi), northeastern China (Heilongjiang and Jilin), eastern Russia (South Primorye), northeastern Japan (Setamai, Kamiyasse–Imo, Kesennuma, Ogatsu and Takakurayama in the South Kitakami Belt), central Japan (Moribu and Oguradani in the Hida Gaien Belt and Hitachi), southwestern Japan (Mizukoshi in central Kyushu), eastern China (Zhejiang, Anhui and Jiangxi), central-southern China (Hubei, Hunan, Guangdong and Guangxi), southwestern China (Guizhou, Sichuan, Yunnan and Xizang), Vietnam, Cambodia (Sisophon), Malaysia, Nepal (Kumaon Himalayas), Pakistan (Salt Range) and Greece (Hydra Island).

Family Costispiniferidae Muir-Wood and Cooper, 1960
Subfamily Spinomarginiferinae Waterhouse, 2002
Genus *Spinomarginifera* Huang, 1932

Type species.—*Spinomarginifera kueichowensis* Huang, 1932.

Spinomarginifera kueichowensis Huang, 1932
Fig. 6.10

Spinomarginifera kueichowensis Huang, 1932, p. 56, pl. 5, figs. 1–11; Nakamura, 1959, p. 143, pl. 15, figs. 1–4; Chi-Thuan, 1962, p. 493, pl. 2, fig. 1; Jin et al., 1974, p. 312, pl. 164, fig. 13; Tazawa, 1976, pl. 2, fig. 1; Yang et al., 1977, p. 349, pl. 139, fig. 11; Feng and Jiang, 1978, p. 252, pl. 89, figs. 5, 6; Tong, 1978, p. 222, pl. 79, fig. 5; Zhan, 1979, p. 80, pl. 11, figs. 14–17, 20; Liu et al., 1982, p. 184, pl. 131, figs. 8–10; Wang et al., 1982, p. 219, pl. 92, fig. 3; Wang, 1984, p. 187, pl. 74, fig. 16; pl. 76, fig. 3; Zeng et al., 1995, pl. 5, fig. 10; Chen in Chen et al., 2006, p. 314, fig. 8; Shen and Shi, 2009, p. 158, figs. 3DD, 3EE, 4I; Tazawa et al., 2014, p. 381, fig. 2.10.

← **Fig. 6.** Representatives of the Ishinazaka fauna (1). 1, *Kitakamichonetes multicapillatus* Afanasjeva and Tazawa, internal mould of ventral valve, KFM1890. 2, 3, *Transennatia gratiosa* (Waagen); 2a, 2b, 2c, 2d, ventral, anterior, posterior and lateral views of internal mould of ventral valve, KFM1874; 3a, 3b, 3c, dorsal, anterior and lateral views of internal mould of dorsal valve, KFM1883. 4, *Isogramma heritschi* Nakamura, internal mould of dorsal valve, KFM1872. 5, *Urushtenoidea chaoi* (Jin), internal mould of ventral valve, KFM1888. 6, *Dicystoconcha lapparenti* Termier and Termier, internal mould of ventral valve, KFM1868. 7, *Permianella typica* He and Zhu, internal mould of ventral valve, KFM1863. 8, 9, *Schuchertella debaisiensis* Wang and Zhang; 8a, 8b, ventral and dorsal views of internal mould of conjoined shell, KFM1939; 9, latex cast of external mould of dorsal valve, KFM1943. 10, *Spinomarginifera kueichowensis* Huang; 10a, 10b, ventral and dorsal views of internal mould of conjoined shell, KFM1870 (after Tazawa et al., 2014).

Material.—Two specimens, internal moulds of two conjoined shells, KFM1870, 1871.

Remarks.—These specimens are poorly preserved, but can be referred to *Spinomarginifera kueichowensis* Huang, 1932, from the Wuchiapingian of Guizhou, southwestern China, by their transverse outline (length 14 mm, width 30 mm in the larger specimen, KFM1870), strongly geniculated ventral valve, and slightly concave visceral disc of dorsal valve, with a thin, long median septum and diverging elongate adductor scars. The Hitachi specimens most resemble the shells of *S. kueichowensis*, described and figured by Nakamura (1959, p. 143, pl. 15, figs. 1–4) from the lower Kamiyasse Formation of the Kamiyasse–Imo area, South Kitakami Belt.

Distribution.—Wordian–Wuchiapingian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), central Japan (Hitachi), eastern China (Jhejiang and Jiangxi), central-southern China (Hubei, Hunan, Guangdong and Guangxi), southwestern China (Guizhou and Sichuan) and Vietnam (Quang Tri).

Superfamily Echinoconchoidea Stehli, 1954
Family Echinoconchidae Stehli, 1954
Subfamily Juresaniinae Muir-Wood and Cooper, 1960
Tribe Bathymyoniini Lazarev, 1990
Genus *Bathymyonia* Muir-Wood and Cooper, 1960

Type species.—*Productus nevadensis* Meek, 1877.

Bathymyonia ussurica Kotlyar in Licharew and Kotlyar, 1978
Figs. 7.3–7.5

Bathymyonia ussurica Kotlyar in Licharew and Kotlyar, 1978, p. 67, pl. 16, figs. 2, 3; Tazawa et al., 2014, p. 381, figs. 3.3–3.5.
Waagenoconcha xiujumqinqiensis Lee, Gu and Li, 1982, p. 117, pl. 2, figs. 1, 2.
Waagenoconcha noda-lineata Lee, Gu and Li, 1983, p. 72, pl. 3, fig. 11.
Waagenoconcha xiuqiensis Lee, Gu and Li, 1983, pl. 1, figs. 14, 17; pl. 3, figs. 1, 4.
Waagenoconcha (*Yazengoconcha*) *xiujumqinqiensis* (Lee, Gu and Li): Wang and Zhang, 2003, p. 98, pl. 10, figs. 1–9; pl. 11, figs. 1–3; pl. 12, figs. 3, 6; pl. 15, figs. 1–3.

Material.—Five specimens: (1) internal moulds of three conjoined shells, KFM1897–1899; (2) external moulds of two dorsal valves, KFM1900, 1901.

Description.—Shell medium in size for genus, transversely subquadrate in outline, hinge shorter than greatest width at slightly anterior to midlength; length about 58 mm, width about 71 mm in the largest specimen (KFM1897). Ventral valve strongly and unevenly

convex in lateral profile, most convex at umbonal region, gently convex on visceral disc, moderately geniculated at anterior margin and followed by long trail; sulcus wide and shallow; lateral slopes steep. Dorsal valve with flatly concave visceral disc, geniculated and followed by short trail; fold narrow and low. External ornament of dorsal valve consisting of numerous quincuncially arranged spine bases and irregular concentric rugae; the latter occurring near anterior valve margin. Ventral interior with large flabellate and longitudinally striated diductor scars, and small, elongate and dendritic adductor scars. Dorsal interior with large cardinal process supported by short, strong lateral ridges; median septum long, extending two-thirds valve length; adductor scars large, strongly dendritic.

Remarks.—These specimens can be referred to *Bathymyonia ussurica* Kotlyar in Licharew and Kotlyar, 1978, from the upper Barabashevka Formation of South Primorye, eastern Russia, by their transverse outline and very short hinge of the shells. Some *Bathymyonia* species, described or figured from the Zhesi Formation of the Ujimqinqi area, Inner Mongolia, as *Waagenoconcha xiujumqinqiensis* Lee, Gu and Li, 1982, *Waagenoconcha noda-lineata* Lee, Gu and Li, 1983, and *Waagenoconcha xiuqiensis* Lee, Gu and Li, 1983, are junior synonym of *Bathymyonia ussurica*. *Bathymyonia neimongolica* (Wang and Zhang, 2003), originally described from the Zhesi Formation of the Xiujimqinqi area, Inner Mongolia, is readily distinguished from the present species by its much elongate outline.

Distribution.—Wordian–Capitanian: northern China (Inner Mongolia), eastern Russia (South Primorye) and central Japan (Hitachi).

Bathymyonia neimongolica (Wang and Zhang, 2003)
Figs. 7.1, 7.2

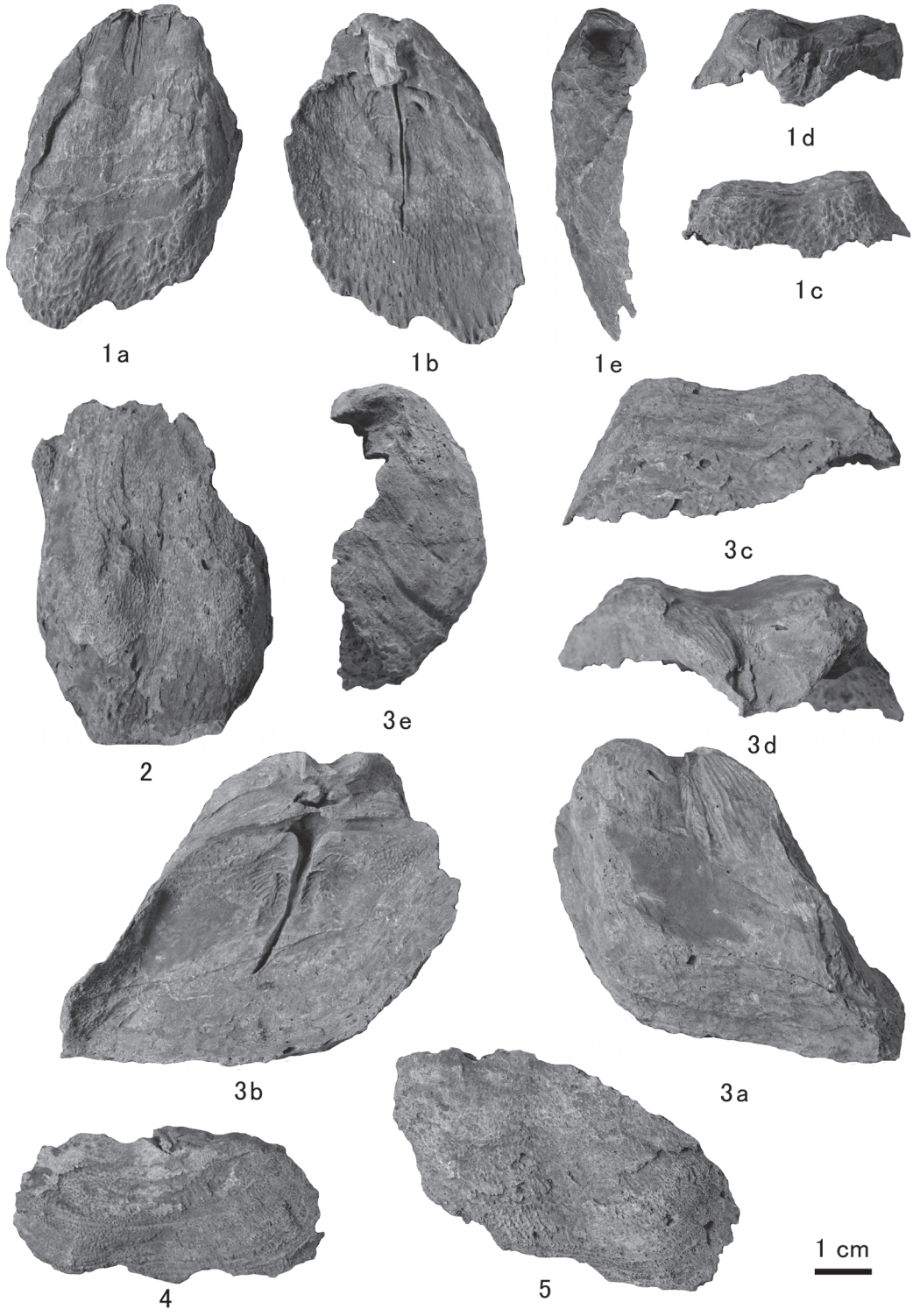
Waagenoconcha imperfecta Prendergast: Tazawa, 1974, p. 127, pl. 3, fig. 2 only; Shiino and Suzuki, 2007, figs. 3–6.

Waagenoconcha (*Yazengoconcha*) *neimongolica* Wang and Zhang, 2003, p. 97, pl. 8, figs. 1–8; pl. 9, figs. 1–4; pl. 14, figs. 4–7.

Bathymyonia neimongolica (Wang and Zhang, 2003): Tazawa, 2014, p. 17, figs. 3.1–3.4; Tazawa et al., 2014, p. 381, figs. 3.1, 3.2.

Material.—Six specimens: (1) internal moulds of five conjoined shells, KFM1891–1895; (2) external mould of a dorsal valve, KFM1896.

Description.—Shell medium in size for genus, elongate subrectangular in outline, with greatest width slightly anterior to midlength; length about 70 mm, width about 35 mm in the largest specimen (KFM1895). Ventral valve strongly and unevenly convex in both lateral and anterior profiles; umbo large, strongly incurved; visceral disc gently convex, moderately geniculated and followed by long trail; sulcus narrow and deep; lateral slopes steep. Dorsal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1 cm

valve gently concave in visceral disc, geniculated at anterior margin and followed by short trail; fold narrow and low on whole valve. External surface of dorsal valve ornamented by numerous elongate and quincuncially arranged spine bases and irregularly developed concentric rugae. Ventral interior with large, flabellate and longitudinally striated diductor scars, and elongate, dendritic adductor scars set on elevated ridges. Dorsal interior with massive cardinal process, supported by short, broad lateral ridges; median septum long, extending two-thirds valve length; adductor scars strongly dendritic.

Remarks.—These specimens are referred to *Bathymyonia neimongolica* (Wang and Zhang, 2003), from the Zhesi Formation of Inner Mongolia, on account of the elongate subrectangular outline, gently convex visceral region and steep lateral slopes of the ventral valve, and in having enormously large cardinal process and short, broad lateral ridges in the dorsal valve. The type species, *Bathymyonia nevadensis* (Meek, 1877), from the Phosphoria Formaion of Wyoming, Utah and Nevada, USA, is distinguished from *B. neimongolica* by its smaller, less elongate and more evenly convex ventral valve.

Distribution.—Wordian–Capitanian: northern China (Inner Mongolia), northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt) and central Japan (Hitachi).

Superfamily Aulostegoidea Muir-Wood and Cooper, 1960
Family Echinostegidae Muir-Wood and Cooper, 1960
Subfamily Chonosteginae Muir-Wood and Cooper, 1960
Genus *Urushtenoidea* Jin and Hu, 1978

Type species.—*Urushtenia chaoi* Jin, 1963.

Urushtenoidea chaoi (Jin, 1963)
Fig. 6.5

Urushtenia chaoi Jin, 1963, p. 15, 28, pl. 1, figs. 1–4, 9–12; pl. 2, figs. 7, 8, 13–17.
Urushtenoidea chaoi (Jin): Jin and Hu, 1978, p. 116, pl. 2, fig. 10; Tong, 1978, p. 218, pl. 78, fig. 18; Nakamura, 1979, p. 230, pl. 2, fig. 4; Hu, 1983, pl. 3, fig. 6; Zeng, 1992, pl. 1, figs. 9–11; Sone et al., 2001, p. 184, figs. 5.7–5.14, 5.16–5.18; Tazawa et al., 2014, p. 383, fig. 2.5.

Material.—One specimen, internal mould of a ventral valve, KFM1888.

← **Fig. 7.** Representatives of the Ishinazaka fana (2). 1, 2, *Bathymyonia neimongolica* (Wang and Zhang); 1a, 1b, 1c, 1d, 1e, ventral, dorsal, anterior, posterior and lateral views of internal mould of conjoined shell, KFM1893; 2, external mould of dorsal valve, KFM1896. 3–5, *Bathymyonia ussurica* Kotlyar; 3a, 3b, 3c, 3d, 3e, ventral, dorsal, anterior, posterior and lateral views of internal mould of conjoined shell, KFM1897; 4, external mould of dorsal valve, KFM1901; 5, external mould of dorsal valve, KFM1900 (after Tazawa et al., 2014).

Remarks.—This specimen can be identified with *Urushtenoidea chaoi* (Jin, 1963), from the upper Chihsian to the lower Maokouan of Anhui and Jiangxi, eastern China, by its small size (length 20 mm, width 15 mm), strongly convex and geniculate ventral valve with a narrow and deep sulcus, and the external ornament consisting of strong costae on trail, numbering 14 on each lateral slope and 8 in sulcus.

Distribution.—Roadian–Capitanian: central Japan (Hitachi), eastern China (Jiansu, Anhui and Jiangxi), southwestern China (Sichuan), Cambodia and Malaysia.

Superfamily Linoproductoidea Stehli, 1954
Family Linoproductidae Stehli, 1954
Subfamily Linoproductinae Stehli, 1954
Genus *Linoproductus* Chao, 1927

Type species.—*Productus cora* d'Orbigny, 1842.

Linoproductus sp.
Fig. 8.6

Linoproductus sp. Tazawa et al., 2014, p. 383, fig. 4.6.

Material.—One specimen, internal mould of a ventral valve, KFM1869.

Remarks.—The single ventral valve specimen from Hitachi is medium in size, and elongate oval in outline, with the greatest width at about two-thirds length from umbo; length 47 mm, width 30 mm. External surface of ventral valve is ornamented by numerous fine costellae and some strong concentric rugae, which occurring near anterior margin of the valve. This specimen is safely assigned to the genus *Linoproductus* Stehli, 1954, by its size, outline and external ornament of the ventral valve. But the specific identification is difficult owing to ill preservation of the present material.

Suborder Lyttoniidina Williams, Harper and Grant, 2000
Superfamily Permianelloidea He and Zhu, 1979
Family Permianellidae He and Zhu, 1979
Genus *Permianella* He and Zhu, 1979

Type species.—*Permianella typica* He and Zhu, 1979.

Permianella typica He and Zhu, 1979
Fig. 6.7

Permianella typica He and Zhu, 1979, p. 132, 137, pl. 1, fig. 1; pl. 2, figs. 1–3; pl. 3, figs. 1–3; Wang and Jin, 1991, p. 496, pl. 2, figs. 1–3; Zeng et al., 1995; pl. 21, fig. 16; Shen and Tazawa, 1997, p. 288, figs. 2–4, 5.1–5.14; Campi et al., 2005, p. 127, pl. 4, figs. I, J; Tazawa, 2008b, p. 50, fig. 8.1; Tazawa et al., 2014, p. 383, fig. 2.7.
Permianella sp. He and Zhu, 1979, p. 133, 139, pl. 1, figs. 2, 3.

Material.—Five specimens, internal moulds of five ventral valves, KFM1863–1867.

Remarks.—These specimens are referred to *Permianella typica* He and Zhu, 1979, originally described from the Longtan Formation of Jiangxi, eastern China and Sichuan, southwestern China, by their unique elongate bilobate shells (length 35 mm, width 18 mm in the largest specimen, KFM1863), with narrow ventral sulcus and deep incision. *Permianella* sp. He and Zhu, 1979, from the Longtan Formation of Jiangsu, eastern China, is similar in size and shape of the shell, and can be referred to *P. typica*.

Distribution.—Wordian–Wuchiapingian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), central Japan (Hitachi), southwestern Japan (Mizukoshi in central Kyushu), eastern China (Zhejiang and Jiangxi), southwestern China (Sichuan) and Malaysia (Pahang).

Genus *Dicystoconcha* Termier and Termier in Termier et al., 1974

Type species.—*Dicystoconcha lapparenti* Termier and Termier in Termier et al., 1974.

Dicystoconcha lapparenti Termier and Termier in Termier et al., 1974
Fig. 6.6

Dicystoconcha lapparenti Termier and Termier in Termier et al., 1974, p. 123, pl. 22, figs. 1, 2; text-fig. 22; Wang and Jin, 1991, p. 495, pl. 1, figs. 1–9; pl. 3, figs. 1–7; Shen and Tazawa, 2014, p. 248, figs. 3.1–3.5; Tazawa et al., 2014, p. 383, fig. 2.6.
Dipunctella contracta Liang in Wang et al., 1982, p. 229, pl. 102, fig. 3.
Guangjiayanella guangjiayanensis Yang, 1984, p. 212, pl. 31, figs. 11–16; text-fig. 5.9.
Guangdongina xiamaoensis Mou and Liu, 1989, p. 458, pl. 1, figs. 1–9; pl. 2, figs. 1–7; text-fig. 5.
Guangdongina leguminiformis Mou and Liu, 1989, p. 458, pl. 3, figs. 4–8.
Guangdongina perforatus Mou and Liu, 1989, p. 459, pl. 2, fig. 8; pl. 3, figs. 1–3.
Guangdongina sp. Mou and Liu, 1989, p. 459, pl. 2, fig. 9.
Paritisteges latesulcata Liang, 1990, p. 380, pl. 42, figs. 1, 2.
Fabulasteges planata Liang, 1990, p. 381, pl. 42, figs. 3, 4.

Material.—One specimen, internal mould of a ventral valve, KFM1868.

Remarks.—This specimen is referred to *Dicystoconcha lapparenti* Termier and Termier

in Termier et al., 1974, from the lower Murgabian of Wardak, central Afghanistan, in its small, ovate and bilobate ventral valve (length 13 mm, width 12 mm), with shallow incision and a distinct central platform.

Distribution.—Kungurian–Wuchiapingian: Afghanistan, northern China (Inner Mongolia), northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), central Japan (Hitachi), eastern China (Zhejiang) and central-southern China (Hubei and Guangdong).

Order Orthotetida Waagen, 1884
Suborder Orthotetidina Waagen, 1884
Superfamily Orthotetoidea Waagen, 1884
Family Schuchertellidae Williams, 1953
Subfamily Schuchertellinae Williams, 1953
Genus *Schuchertella* Girty, 1904

Type species.—*Streptorhynchus lens* White, 1862.

Schuchertella debaisiensis Wang and Zhang, 2003
Figs. 6.8, 6.9

Schuchertella debaisiensis Wang and Zhang, 2003, p. 122, pl. 27, figs. 1–9: pl. 29, figs. 1, 2; Tazawa et al., 2014, p. 383, figs. 2.8, 2.9.

Material.—Seven specimens: (1) internal moulds of two conjoined shells, KFM1939, 1940; (2) external and internal moulds of a dorsal valve, KFM1941; (3) external moulds of two dorsal valves, KFM1942, 1943; (5) internal moulds of two dorsal valves, KFM1944, 1945.

Description.—Shell medium in size for genus, transversely elliptical in outline, with greatest width slightly anterior to hinge; length about 33 mm, width about 35 mm in the largest specimen (KFM1939). Ventral valve gently convex in both anterior and lateral profiles; umbo narrow, slightly projected; interarea moderately high, triangular; ears small, nearly flat; sulcus absent. Dorasl valve slightly convex, without fold. External surface of dorsal valve ornamented by numerous costellae and some irregular concentric rugae; costellae often intercalated, numbering 5–6 in 2 mm at about midlength. Dorsal interior with a pair of diverging socket ridges; adductor scars impressed and subdivided by a low myophragm.

Remarks.—These specimens are referred to *Schuchertella debaisiensis* Wang and Zhang, 2003, from the Dashizai and Zhesi (Jisu) formations of Inner Mongolia, by size, shape and external ornament of the dorsal valves, in particular, by the slightly convex profile. *Schuchertella semiplana* (Waagen, 1884, p. 608, pl. 55, figs. 1, 2), from the Chhidru Formation

of the Salt Range, differs from the present species in having flat dorsal valve.

Distribution.—Kungurian–Wordian: northern China (Inner Mongolia) and central Japan (Hitachi).

Order Rhynchonellida Kuhn, 1949
Superfamily Wellerelloidea Licharew, 1956
Family Wellerellidae Licharew, 1956
Subfamily Uncinunellininae Savage, 1996
Genus *Uncinunellina* Grabau, 1932

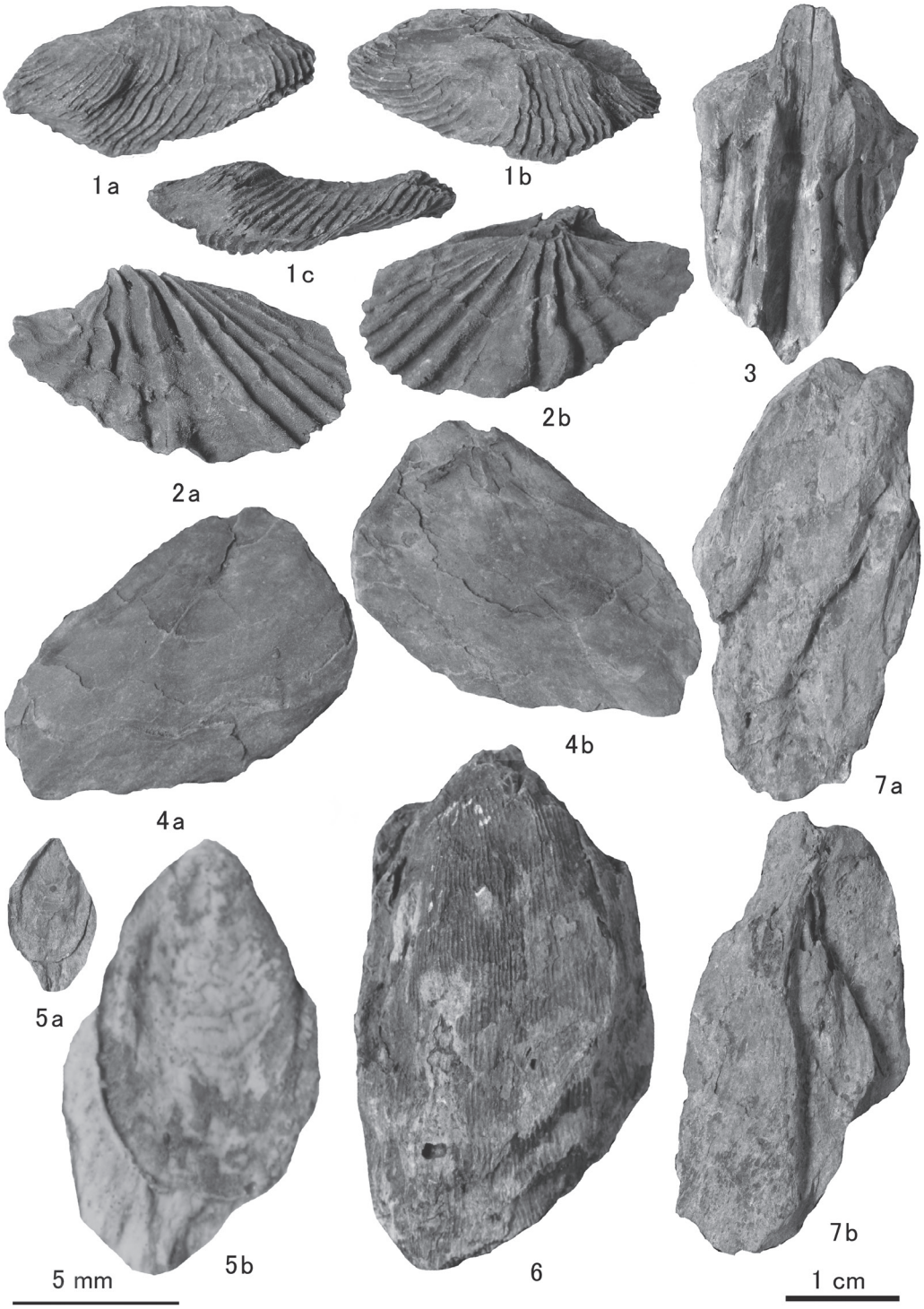
Type species.—*Uncinulus theobaldi* Waagen, 1883.

Uncinunellina timorensis (Beyrich, 1865)
Fig. 8.1

Rhynchonella timorensis Beyrich, 1865, p. 72, pl. 1, fig. 10.
Uncinulus theobaldi Waagen, 1883, p. 425, pl. 34, fig. 1.
Rhynchonella (*Uncinulus*) *timorensis* Beyrich: Rothpletz, 1892, p. 84, pl. 10, fig. 6; Hamlet, 1928, p. 62, pl. 10, figs. 3–7.
Uncinulus timorensis Beyrich: Diener, 1897, p. 69, pl. 10, figs. 7–10.
Uncinunellina timorensis (Beyrich): Zhang and Ching (Jin), 1961, p. 404, pl. 1, figs. 9–16; Yang et al., 1977, p. 378, pl. 150, fig. 2; Jin et al., 1979, p. 100, pl. 30, figs. 21–27; Zhan, 1979, p. 95, pl. 8, fig. 9; pl. 10, fig. 4; Liu et al., 1982, p. 192, pl. 138, fig. 11; Wang et al., 1982, p. 233, pl. 84, fig. 3; pl. 93, fig. 5; Xu, 1987, p. 230, pl. 14, figs. 7–9; pl. 15, figs. 1–3; Zeng et al., 1995, pl. 12, figs. 9, 10; Shen and Shi, 2007, p. 46, pl. 17, figs. 31–42; text-fig. 11; Tazawa et al., 2014, p. 385, fig. 4.1.
Uncinunellina theobaldi (Waagen): Grant, 1976, pl. 48, figs. 1–9; Yang et al., 1977, p. 378, pl. 150, fig. 5; Zeng et al., 1995, pl. 12, fig. 11; Chen, 2004, p. 55, pl. 11, figs. 30–33.

Material.—Twenty-five specimens: (1) internal moulds of twenty-one conjoined shells, KFM1911–1931; (2) external moulds of two ventral valves, KFM1932, 1933; (2) external moulds of two dorsal valves, KFM1934, 1935.

Description.—Shell medium in size for genus, transversely pentagonal to elliptical in outline; widest at midlength; length 14 mm, width 27 mm in the largest specimen (KFM1911). Ventral valve gently convex in visceral region, strongly geniculated, and followed by long trail (tongue); umbo small, pointed; sulcus wide and deep, with flat to slightly round bottom; lateral flanks gently convex. Dorsal valve moderately convex, strongly geniculated at anterior margin, and followed by short trail; fold wide and high; flanks gently convex.


1a
1b
1c
2a
2b
3
4a
4b
5a
5b
6
7a
7b
5 mm
1 cm

External surface of both valves ornamented by numerous costae, numbering 8–11 in sulcus and 9–11 on each flank; costae flattened anteriorly and faintly grooved medianly as traces of very fine spines of the opposite valve. Internal structures of both valves not well preserved.

Remarks.—These specimens are referred to *Uncinunellina timorensis* (Beyrich, 1865), from the upper Permian (Wuchiapingian?) of western Timor, by their size, shape and external ornament of the shells. *Uncinunellina theobaldi* (Waagen, 1883), from the Wargal Formation of the Salt Range, is a junior synonym of the present species (Diener, 1897, p. 69). *Uncinunellina multicostifera* Xu and Grant (1994, p. 35, figs. 21, 22.1–22.27), from the Changhsingian of Zhejiang (eastern China), Hubei (central-southern China) and Sichuan (southwestern Chia), is distinguished from *U. theobaldi* by its more numerous costae on both ventral and dorsal valves.

Distribution.—Asselian–Changhsingian; northwestern China (Xinjiang and Qinghai), central Japan (Hitachi), eastern China (Anhui and Jiangxi), cntral-southern China (Hubei, Hunan and Guangdong), southwestern China (Guizhou, Sichuan and Xizang), Pakistan (Salt Range) and Indonesia (Timor).

Order Athyridida Boucot, Johnson and Staton, 1964
Suborder Athyrididina Boucot, Johnson and Staton, 1964
Superfamily Athyridoidea Davidson, 1881
Family Athyrididae Davidson, 1881
Subfamily Cleiothyridininae Alvarez, Rong and Boucot, 1998
Genus *Cleiothyridina* Buckman, 1906

Type species.—*Atrypa pectinifera* Sowerby, 1840.

Cleiothyridina sp.
Fig. 8.5

Cleiothyridina sp. Tazawa et al., 2014, p. 385, fig. 4.5.

Material.—Two specimens: (1) external mould of a ventral valve, KFM1946, (2) internal

← **Fig. 8.** Representatives of the Ishinazaka fana (3). 1, *Uncinunellina timorensis* (Beyrich); 1a, 1b, 1c, ventral, dorsal and anterior views of internal mould of conjoined shell, KFM1911. 2, *Spiriferellina fredericksi* Tazawa; 2a, 2b, ventral and dorsal views of internal mould of conjoined shell, KFM1904. 3, *Spiriferella* sp., internal mould of ventral valve, KFM1889. 4, *Martinia* sp.; 4a, 4b, ventral and dorsal views of internal mould of conjoined shell, KFM1936. 5, *Cleiothyridina* sp.; 5a, 5b, external mould and external latex cast of ventral valve, KFM1946. 6, *Linoproductus* sp., internal mould of ventral valve, KFM1869. 7, *Whitspakia* sp.; 7a, 7b, ventral and dorsal views of internal mould of conjoined shell, KFM1902. The scale bar (1 cm) is applied to all figures except for 5b; and the another scale bar (5 mm) is applied to fig. 5b only (after Tazawa et al., 2014).

mould of a dorsal valve, KFM1947.

Remarks.—These specimens are safely assigned to the genus *Cleiothyridina* by the small, longitudinally ovate shell (length 12 mm, width 9 mm in the ventral valve specimen, KFM1946), and the external ornament consisting of numerous concentric lamellae, projecting anteriorly as long flat spines. The Hitachi species most resembles *Cleiothyridina aculeata* Fang (in Fang and Fan, 1994, p. 85, pl. 23, figs. 6–7; pl. 30, fig. 11; pl. 31, figs. 1, 2), from the lower Permian (Sakmarian–Artinskian) of western Yunnan, southwestern China, in its small size and flattened ventral valve, although accurate comparison is difficult owing to ill preservation of the present material.

Order Spiriferida Waagen, 1883
Suborder Spiriferidina Waagen, 1883
Superfamily Martinioidea Waagen, 1883
Family Martiniidae Waagen, 1883
Subfamily Martiniinae Waagen, 1883
Genus *Martinia* M'Coy, 1844

Type species.—*Spirifer glaber* Sowerby, 1820.

Martinia sp.
Fig. 8.4

Martinia sp. Tazawa et al., 2014, p. 385, fig. 4.4.

Material.—Three specimens: (1) internal moulds of two conjoined shells, KFM1936, 1937; (2) internal mould of a ventral valve, KFM1938.

Remarks.—These specimens are safely assigned to the genus *Martinia* by their subcircular, gently convex shells, with distinct vascular impressions in both ventral and dorsal valves. The Hitachi specimens resemble *Martinia semiplana* Waagen (1883, p. 536, pl. 43, fig. 4), from the Wargal Formation of the Salt Range, in size and shape of the shell. However, accurate comparison is difficult because of lacking the external information in the present specimens.

Superfamily Spiriferoidea King, 1846
Family Spiriferellidae Waterhouse, 1968
Genus *Spiriferella* Tschernyschew, 1902

Type species.—*Spirifer saranae* de Verneuil, 1845.

Spiriferella sp.
Fig. 8.3

Spiriferella sp. Tazawa et al., 2014, p. 385, fig. 4.3.

Material.—One specimen, internal mould of a ventral valve, KFM1889.

Remarks.—The single specimen from Hitachi is safely assigned to the genus *Spiriferella* by its medium-sized, longer shell (length about 35 mm, width about 22 mm), with 3–4 simple coarse costae on each side of the ventral valve, and in having a deeply impressed, heart-shaped muscle field. However the specific identification is difficult owing to ill state of preservation of the present material.

Order Spiriferinida Ivanova, 1972
Suborder Spiriferinidina Ivanova, 1972
Superfamily Pennospiriferinoidea Dagys, 1972
Family Spiriferellinidae Ivanova, 1972
Genus *Spiriferellina* Fredericks, 1924a

Type species.—*Terebratulites cristatus* Schlotheim, 1816.

Spiriferellina fredericksi Tazawa, 2014
Fig. 8.2

Spiriferina cristata (Schellwien): Hayasaka, 1922, p. 66, pl. 9, figs. 5–9.
Spiriferina cristata (von Schlotheim): Hayasaka, 1960, p. 53, pl. 1, fig. 10.
Spiriferellina cristata biplicata (Davidson): Fredericks, 1924b, p. 35, pl. 1, fig. 15.
Spiriferellina cristata (Schlotheim): Tazawa, 1976, pl. 2, fig. 3; Minato et al., 1979, pl. 67, figs. 4, 5.
Spiriferellina fredericksi Tazawa, 2014, p. 19, figs. 3.5–3.7; Tazawa et al., 2014, p. 385, fig. 4.2.

Material.—Eight specimens: (1) internal mould of a conjoined shell, with external mould of the dorsal valve, KFM1903; (2) internal mould of a conjoined shell, KFM1904; (3) a ventral valve, KFM1905; (4) external mould of a ventral valve, KFM1906; (5) internal mould of two ventral valves, KFM1907, 1908; (6) external mould of a dorsal valve, KFM1909; (7) internal mould of a dorsal valve, KFM1910.

Description.—Shell large in size for genus, transversely subelliptical in outline; widest at or near hinge; cardinal extremities acute; length about 21 mm, width about 44 mm in the best preserved specimen (KFM1903). Ventral valve moderately convex in lateral profile,

most convex in umbonal region, somewhat flattened in visceral region; interarea broadly triangular; sulcus broad and deep, with flattened bottom. Dorsal valve slightly convex in lateral profile, but nearly flat in anterior profie, except for broad and high fold. External surface of both valves ornamented by strong, simple, rounded costae, numbering 5–6 pairs in both valves; growth laminae irregularly developed, more densely in anterior region; numerous very fine pustules on whole surface of both valves. Ventral interior with a pair of short adminicula, slightly divergent; median septum high and long, extending to midlength of valve. Other internal structures of both valves are not well preserved.

Remarks.—These species are referred to *Spiriferellina fredericksi* Tazawa, 2014, from the lower Kamiyasse Formation of the South Kitakami Belt, by their large size, transverse outline and in having rather numerous costae on both ventral and dorsal valves. This species is distinguished from *Spiriferellina cristata* (von Schlotheim, 1816) by its larger size, transverse outline and in having more numerous costae on both ventral and dorsal valves. *Spiriferellina sonorensis* Cooper (1953, p. 69, pl. 21C, figs. 13–27; pl. 22D, figs. 26–29), from the Monos Formation (Kungurian) of El Antimonio, Mexico, is also a large, transverse species of *Spiriferellina*, but the Mexican species differs from *S. fredericksi* in having strongly mucronate cardinal extremities.

Distribution.—Wordian: eastern Russia (South Primorye), northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt) and central Japan (Hitachi).

Order Terebratulida Waagen, 1883
Suborder Terebratulidina Waagen, 1883
Superfamily Dielasmatoidea Schuchert, 1913
Family Dielasmatidae Schuchert, 1913
Subfamily Dielasmatinae Schuchert, 1913
Genus *Whitspakia* Stehli, 1964

Type species.—*Dielasma biplex* Waagen, 1882.

Whitspakia sp.
Fig. 8.7

Whitspakia sp. Tazawa et al., 2014, p. 385, fig. 4.7.

Material.—One specimen, internal mould of a conjoined shell, KFM1902.

Remarks.—This specimen can be assigned to the genus *Whitspakia* by its elongate subpentagonal shell (length about 41 mm, width about 21 mm), having an acute, strongly incurved ventral umbo, shallow ventral sulcus with median costa and low dorsal fold. The

Hitachi species resembles *Dielasma* sp. Tazawa (1979, p. 30, pl. 5, fig. 5), from the lower Kamiyasse Formation of Matsukawa in the Kesennuma area, South Kitakami Belt, in having a prominent fold in the dorsal valve. But accurate comparison is difficult for the poorly preserved specimen.

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