Late Permian (Changhsingian) brachiopod fauna from Maeda in the Ofunato area, South Kitakami Belt, NE Japan

Jun-ichi TAZAWA* and Yukio MIYAKE**

Abstract

A Late Permian (Changhsingian) brachiopod fauna consisting of 15 species in 14 genera is described from the upper Toyoma Formation of Maeda in the South Kitakami Belt, northeast Japan. New species described are *Petasmaia ehiroi, Geyerella ofunatoensis* and *Hustedia minuta*. The Maeda fauna, which is a mixed Boreal–Tethyan–Panthalassan fauna, shows an affinity with Late Permian brachiopod faunas of South Primorye, Northeast China and North China.

Key words: brachiopod, Changhsingian, Maeda, mixed Boreal–Tethyan–Panthalassan fauna, South Kitakami Belt.

Introduction

The latest Permian (Changhsingian) marine faunas are interesting and important because they provide insight into the catastrophic mass extinction that occurred at the P/T boundary. In Japan, Changhsingian brachiopods have been reported from the South Kitakami Belt of northeast Japan (Tazawa, 1975, 1982, 2008a) and the Maizuru Belt (Shimizu, 1961a, 1961b; Tazawa, 2006) and the Akiyoshi Belt (Yanagida, 1996; Tazawa, 2009) of southwest Japan.

This paper describes Changhsingian brachiopods collected by the present authors from the upper part of the Toyoma Formation in the South Kitakami Belt, at Loc. B in Maeda (see Fig. 1), Ikawa-cho, Ofunato City, Iwate Prefecture, northeast Japan. In previous studies, Ehiro (1996)

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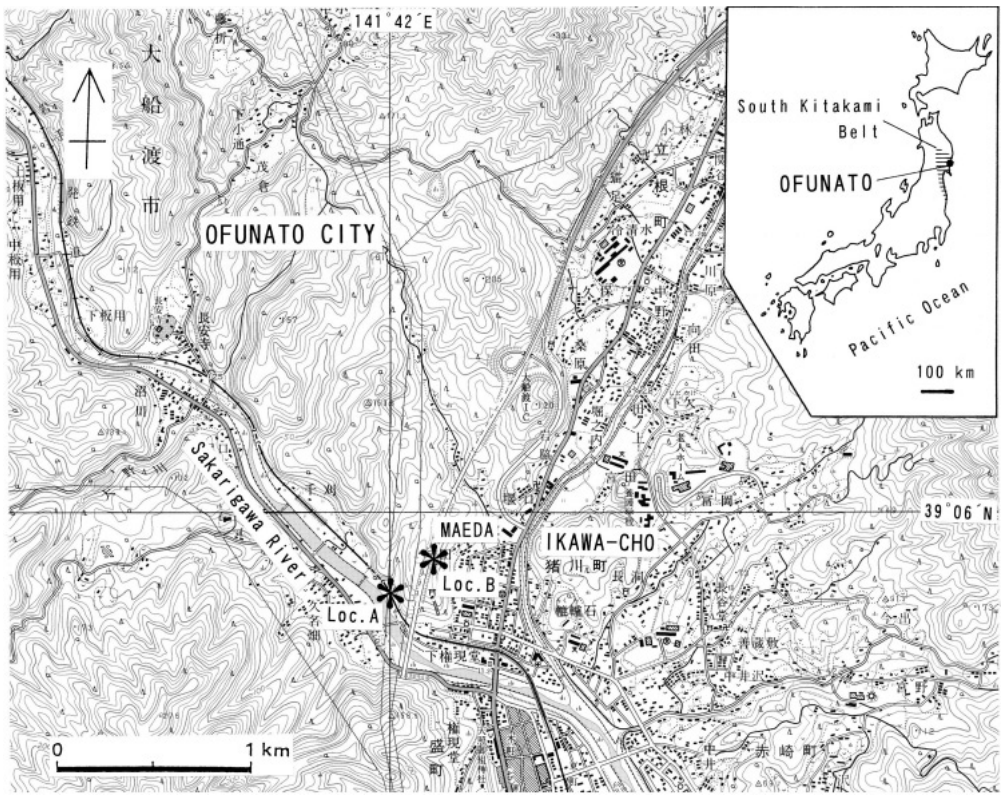


Fig. 1. Index map showing the fossil localities (Loc. A, Loc. B) of Maeda in the Ofunato area, South Kitakami Belt (after Tazawa, 2008a).

described two ammonoid species, *Paratirolites compressus* Ehiro and *Paratirolites* sp., from Loc. A and Loc. B at Maeda, respectively, and documented uppermost Permian (Changhsingian) beds in the Maeda area based on the ammonoid fossil evidence. Nakazawa (1998) described two bivalve species, *Girtypecten* cf. *beipeiensis* Liu and *Etheripecten*? sp., from Loc. B, and noted their resemblance to Changhsingian bivalve species of South China. However, Tazawa (2008a) described a bipolar (antitropical) type brachiopod species, *Lamnimargus peregrinus* (Fredericks), from both Loc. A and Loc. B, indicating a palaeobiogeographical relationship between South Kitakami and Northeast Asia in the Middle to Late Permian, including South Primorye (eastern Russia), Northeast China and North China.

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

The Maeda fauna

The brachiopods from Maeda that are described in the present paper, along with the number of specimens, are as follows:

Tethyochonetes sp. 1
Lamnimargus peregrinus (Fredericks, 1924) 5
Compressoproductus cf. *mytiloides* (Waagen, 1884) 1
Richthofenia sp. 3
Petasmaia ehiroi sp. nov. 2
Derbyia sp. 1
Geyerella ofunatoensis sp. nov. 8
Geyerella sp. 1
Tropidelasma sp. 3
Enteletes andrewsi Grabau, 1931 5
Orthotichia sp. 1
Hustedia minuta sp. nov. 3
Attenuatella sp. 1
Choristitella wynnei (Waagen, 1883) 1
Callispirina sp. 3

Among these species, *Lamnimargus peregrinus*, *Geyerella ofunatoensis* and *Enteletes andrewsi* are abundant; *Richthofenia* sp., *Tropidelasma* sp. and *Hustedia minuta* are common; and the other species are rare.

A Lopingian (Wuchiapingian-Changhsingian) age is indicated by the occurrence of *Tethyochonetes* sp. and *Lamnimargus peregrinus*. *Compressoproductus* cf. *mytiloides* and *Choristitella wynnei* also probably indicate a Lopingian age.

In terms of palaeobiogeography, the Maeda fauna includes three Boreal- or bipolar-type genera (*Lamnimargus*, *Attenuatella* and *Choristitella*), three Tethyan-type genera (*Tethyochonetes, Richthofenia* and *Geyerella*) and two Panthalassan (North American)-type genera (*Petasmaia* and *Tropidelasma*). Consequently, the Maeda fauna is a mixed Boreal–Tethyan–Panthalassan fauna. The brachiopods from Maeda probably inhabited a mid-latitude region in the Northern Hemisphere during the Late Permian (Changhsingian), near North China (Sino-Korea); i.e., the eastern part of the Inner Mongolia-Japan Transitional Zone (Tazawa, 1991, 2001).

Systematic descriptions

(by JT)

Order Productida Sarytcheva and Sokolskaya, 1959
Suborder Chonetidina Muir-Wood, 1955
Superfamily Chonetoidea Bronn, 1862
Family Rugosochonetidae Muir-Wood, 1962
Subfamily Rugosochonetinae Muir-Wood, 1962
Genus *Tethyochonetes* Chen, Shi, Shen and Archbold, 2000

Type species.—*Waagenites soochowensis quadrata* Zhan, 1979.

Tethyochonetes sp.
Figs. 2.1a, 2.1b

Material.—One specimen, external mould of a dorsal valve, NU-B1479.

Remarks.—This specimen is assigned to the genus *Tethyochonetes* by its small size, transversely subquadrate outline (length about 6 mm, width about 12 mm), and numerous simple, rounded costellae (8-9 in 3 mm at the midvalve) on the dorsal valve. The Maeda species superficially resembles *Tethyoconetes wongiana* (Chao, 1928, p. 28, pl. 1, figs. 17a, 17b), from the Lopingian of Guizhou, South China, in its subquadrate outline and in having large, pointed ears. But specific identification is difficult for the poorly preserved specimen.

Suborder Productidina Waagen, 1883
Superfamily Productoidea Gray, 1840
Family Productellidae Schuchert, 1929
Subfamily Marginiferinae Stehli, 1954
Tribe Paucispiniferini Muir-Wood and Cooper, 1960
Genus *Lamnimargus* Waterhouse, 1975

Type species.—*Marginifera himalayensis* Diener, 1899.

Lamnimargus peregrinus (Fredericks, 1924)
Figs. 3.1a-3.3

Paramarginifera peregrina Fredericks, 1924, p. 24, pl. 1, figs. 7, 8; Fredericks, 1925, p. 12, pl. 1, figs. 41-44.
Dictyoproductus zesiensis Lee and Gu, 1976, p. 256, pl. 167, figs. 5, 6; pl. 170, figs. 1a, 1b.
Probolionia caucasica peregrina (Fredericks): Licharew and Kotlyar, 1978, p. 12, figs. 13, 14.

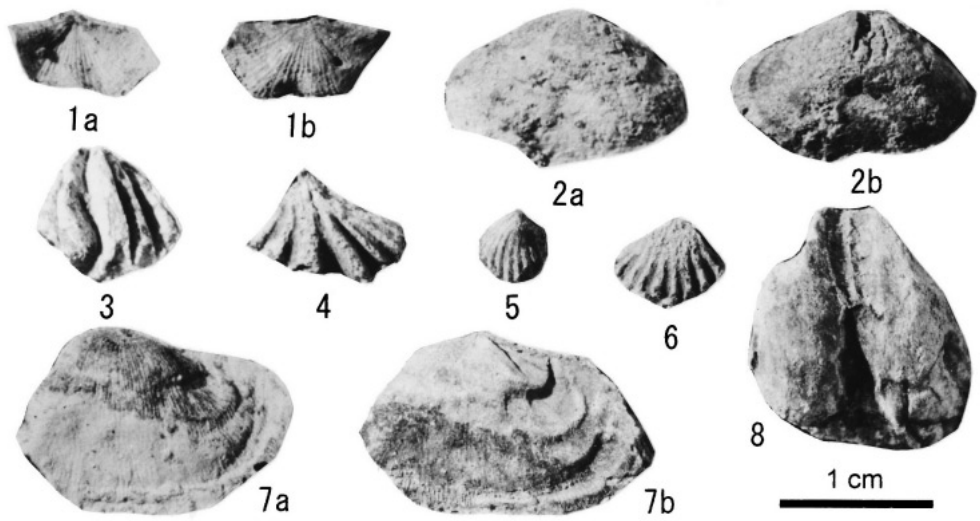


Fig. 2. 1a, 1b: *Tethyochonetes* sp., external latex cast and internal mould of dorsal valve, NU-B1479. 2a, 2b: *Orthotichia* sp., external latex cast and internal mould of ventral valve, NU-B1500. 3, 4: *Callispirina* sp., 3: external latex cast of ventral valve, NU-B1483, 4: internal mould of ventral valve, NU-B1485. 5, 6: *Hustedia minuta* sp. nov., 5: external natural cast of ventral valve, NU-B1472 (holotype), 6: internal mould of dorsal valve, NU-B1474. 7a, 7b: *Derbyia* sp., external latex cast and internal mould of dorsal valve, NU-B1507. 8: *Attenuatella* sp., internal mould of ventral valve, NU-B1475.

Paramarginifera? *peregrina* Fredericks: Duan and Li, 1985, p. 112, pl. 42, figs. 1-7; Lee et al., 1980, p. 356, pl. 166, figs. 18, 28.

Lamnimargus himalayensis (Diener): Kotlyar in Kotlyar et al., 1989, pl. 23, figs. 9a, 9b.

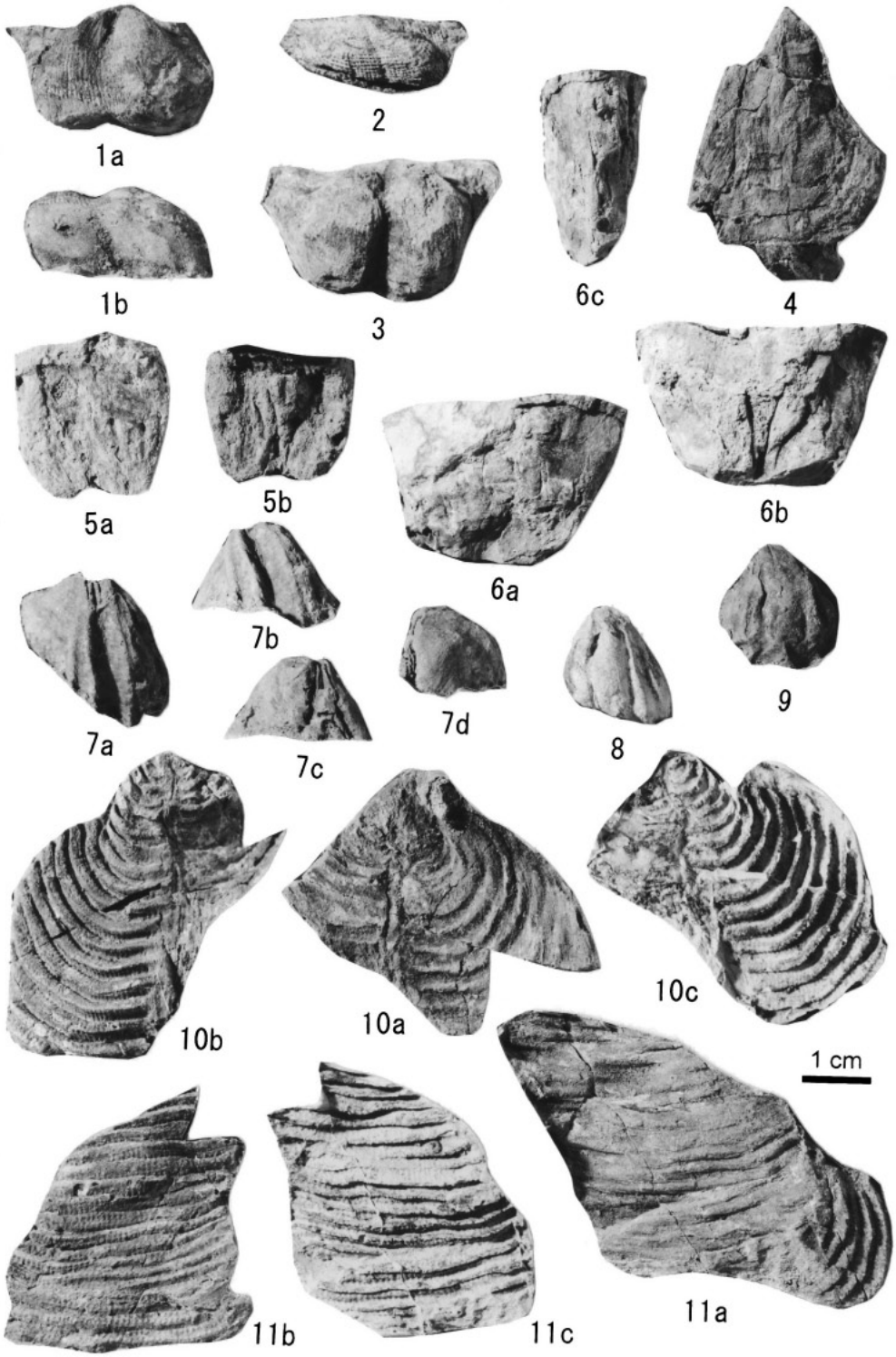
Lamnimargus peregrine (Fredericks): Wang and Zhang, 2003, p. 73, pl. 14, figs. 3, 8, 9; pl. 15, fig. 11; pl. 21, figs. 14-16, 22-24.

Lamnimargus peregrinus (Fredericks): Tazawa, 2008a, p. 7, figs. 3A-3T; Tazawa, 2008b, p. 25, figs. 4.2a-4.4.

Material.—Six specimens: (1) external cast of a ventral valve, NU-B1494; (2) internal moulds of four ventral valves, NU-B1495-1498; (3) external cast of a dorsal valve, NU-B1499.

Remarks.—These specimens are identical with *Lamnimargus peregrinus* (Fredericks, 1924), originally described from the Middle Permian (Wordian-Capitanian) of South Primorye, eastern Russia, by their size, shape and external ornament of the shell. The Maeda specimens are very similar to the shells of *Lamnimargus peregrinus* (Fredericks, 1924), described by Tazawa (2008a, p. 7) from the both localities, Loc. A and Loc. B of Maeda, Ofunato City.

Distribution.—Middle Permian (Wordian-Capitanian) of North China (Inner Mongolia),


1a
2
1b
3
6c
4
5a
5b
6b
6a
7b
9
7a
7d
8
7c
10b
10a
10c
1 cm
11b
11c
11a

Northeast China (Heilongjiang) and eastern Russia (South Primorye); Upper Permian (Lopingian) of eastern Russia (South Primorye) and northeast Japan (Maeda and Takakurayama in the South Kitakami Belt).

Superfamily Linoproductoidea Stehli, 1954
Family Monticuliferidae Muir-Wood and Cooper, 1960
Subfamily Compressoproductinae Jin and Hu, 1978
Genus *Compressoproductus* Sarytscheva in Sarytcheva et al., 1960

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

Compressoproductus cf. *mytiloides* (Waagen, 1884)
Fig. 3.4

Cf. *Productus mytiloides* Waagen, 1884, p. 711, pl. 80, figs. 4a-4d.

Material.—One specimen, internal mould of a ventral valve, with internal mould of posterior region of the dorsal valve, NU-B1508.

Description.—Shell medium size for genus, elongate subtrigonal in outline, with greatest width at about one-third length from anterior margin of valve; length about 45 mm, width about 29 mm. Ventral valve flatly convex in both anterior and lateral profiles. External surface of ventral valve ornamented with strong concentric rugae and numerous fine capillae; rugae numbering 2-3 in 5 mm at about midvalve. Interior of dorsal valve, with a strong median septum.

Remarks.—This specimen most resembles *Compressoproductus mytioides* (Waagen, 1884, p. 711, pl. 80, figs. 4a-4d), from the Chhidru Formation of the Salt Range, in size and shape of the ventral valve, and somewhat irregular concentric rugae with broad interspaces. However, accurate comparison is difficult for the poorly preserved material.

Compressoproductus fenshujiangensis Liang (1990, p. 210, pl. 34, figs. 6-8), from the upper Lengwu Formation (Wuchiapingian) of Lengwu, Zhejiang Province, East China, differs in its much larger dimensions.

⬅ **Fig. 3.** 1a-3: *Lamnimargus peregrinus* (Fredericks), 1a, 1b: ventral and anterior views of internal mould of ventral valve, NU-B1495, 2: external natural cast of dorsal valve, NU-B1499, 3: internal mould of ventral valve, NU-B1496. 4: *Compressoproductus* cf. *mytiloides* (Waagen), internal mould of ventral valve, NU-B1508. 5a-6c: *Richthofenia* sp., 5a, 5b: anterior and posterior views of internal mould of ventral valve, NU-B1471, 6a, 6b, 6c: ventral, posterior and lateral views of internal mould of ventral valve, NU-B1470. 7a-9: *Enteletes andrewsi* Grabau, 7a, 7b, 7c, 7d: ventral, anterior, posterior and lateral views of internal mould of ventral valve, NU-B1502, 8: external natural cast of dorsal valve, NU-B1504, 9: internal mould of dorsal valve, NU-B1506. 10a-11c: *Petasmaia ehiroi* sp. nov., 10a, 10b, 10c: external mould, internal mould and internal latex cast of ventral valve, NU-B1476 (holotype), 11a, 11b, 11c: external mould, internal mould and internal latex cast of ventral valve, NU-B1477.

The type species, *Compressoproductus compressus* (Waagen, 1884, p. 710, pl. 81, figs. 1a-2c), from the Chhidru Formation of the Salt Range, is distinguished from the Kitakami species by its more strongly inflated ventral valve and the concentric rugae with narrower interspaces on the valve.

Superfamily Richthofenioidea Waagen, 1885
Family Richthofeniidae Waagen, 1885
Genus *Richthofenia* Kayser, 1881

Type species.—*Anomia lawrenciana* de Koninck, 1863.

Richthofenia sp.
Figs. 3.5a-3.6c

Material.—Three specimens: (1) external and internal moulds of a ventral valve, NU-B1469; (2) internal moulds of two ventral valves, NU-B1470, 1471.

Remarks.—These specimens are safely assigned to the genus *Richthofenia* by their deep, conical-shaped ventral valve (length about 15 mm, width about 38 mm, height about 24 mm in the largest specimen, NU-B1470), elongate trigonal interarea with distinct pseudodeltidium, and external ornament of strong concentric rugae and numerous fine capillae. The Maeda species most resembles *Richthofenia lawrenciana* (de Koninck, 1863, p. 6, pl. 4, figs. 7-9), from the Wargal Formation of the Salt Range, in size and shape of the ventral valve. But accurate comparison is difficult for the poorly preserved specimens.

Richthofenia mabutii Tazawa and Araki (1984, p. 3, pl. 1, figs. 1-7), from the lower Kanokura Formation of Omotematsukawa in the South Kitakami Belt, differs from the present species in its much smaller size.

Suborder Lyttoniidina Williams, Harper and Grant, 2000
Superfamily Lyttonioidea Waagen, 1883
Family Lyttoniidae Waagen, 1883
Subfamily Lyttoniinae Waagen, 1883
Genus *Petasmaia* Cooper and Grant, 1969

Type species.—*Petasmaia expansa* Cooper and Grant, 1969.

Petasmaia ehiroi Tazawa sp. nov.
Figs. 3.10a-3.11c, 4

Etymology.—Named for Prof. Masayuki Ehiro.

Fig. 4. *Petasmaia ehiroi* sp. nov., longitudinal section of internal latex cast of ventral valve, NU-B1477. Scale bar represents 1 cm.

Material.—Two specimens, external and internal moulds of two ventral valves, NU-B1476 (holotype), 1477.

Diagnosis.—Average-sized *Petasmaia*, with narrowly arranged lateral septa in ventral valve.

Description.—Shell medium size for genus, slightly longer than wide, subtrigonal in outline; length about 52 mm, width about 50 mm in the holotype (NU-B1476). Ventral valve almost flattened in both lateral and anterior profiles. Ventral interior with numerous, regularly and symmetrically arranged lateral septa on both sides of low median septum; lateral septa thin, with acute crests (mostly anguliseptate, but solidiseptate in some septa), straight or strongly inclined towards anterior margin of valve, and dipping to the front at angles 40-60° in lateral profile (Fig. 4), numbering 4 in 10 mm, and totally 16 pairs of septa in the holotype.

Remarks.—*Petasmaia ehiroi* sp. nov. differs from the type species *Petasmaia expansa* Cooper and Grant (1969, p. 10, pl. 2, figs. 15-18; Cooper and Grant, 1974, p. 430, pl. 163, figs. 1-8; pl. 164, figs. 1-16; pl. 165, figs. 1-23; pl. 169, figs. 11-16), from the Cathedral Mountain Formation (Leonardian) of West Texas, in its lateral septa with narrower interspaces.

Order Orthotetida Waagen, 1884
Suborder Orthotetidina Waagen, 1884
Superfamily Orthotetoidea Waagen, 1884
Family Derbyiidae Stehli, 1954
Genus *Derbyia* Waagen, 1884

Type species.—*Derbyia regularis* Waagen, 1884.

Derbyia sp.
Figs. 2.7a, 2.7b

Material.—One specimen, external and internal moulds of a dorsal valve, NU-B1507.

Remarks.—The single dorsal valve specimen from Maeda is assigned to the genus *Derbyia*, on account of its gently convex, transversely elliptical dorsal valve (length 14 mm, width about 22 mm), ornamented with several strong, irregular, concentric rugae and numerous simple costellae (18-19 in 5 mm at about midvalve), increasing by bifurcation and intercalation, and internal structure of strong, wider diverging socket ridges in the dorsal valve. This specimen may be a young shell.

Family Meekellidae Stehli, 1954
Subfamily Meekellinae Stehli, 1954
Genus *Geyerella* Schellwien, 1900a

Type species.—*Geyerella gemmellaroi* Schellwien, 1900a.

Geyerella ofunatoensis Tazawa sp. nov.
Figs. 5.1a-5.6

Etymology.—Named after the fossil locality, Maeda in the Ofunato City.

Material.—Eight specimens: (1) external cast of a ventral valve, NU-B1486; (2) external and internal moulds of a ventral valve, NU-B1487 (holotype); (3) external cast of a dorsal valve, NU-B1488; (4) internal moulds of five dorsal valves, NU-B1489-1493.

Diagnosis.—Average-sized, shallow cone-shaped *Geyerella,* with irregular strong rugae besides numerous costae and costellae on ventral valve.

Description.—Shell medium size for genus, shallow conical, slightly distorted; outline transversely subelliptical; hinge shorter than greatest width at about midvalve; length 29 mm, width 43 mm; height about 15 mm, hinge width 28 mm in the holotype (NU-B1487). Ventral valve shallow cone, with sharp, slightly distorted and strongly incurved umbo, moderately convex in anterior half of valve; interarea narrow, transversely flat, and longitudinally slightly concave. Dorsal valve strongly and unevenly convex in lateral profile; umbo incurved and overhanging hinge line; sulcus wide and shallow. External surface of ventral valve ornamented with numerous costae and costellae, and irregular strong rugae; costae simple, rounded, with broad intercostal spaces, numbering 3-4 in 5 mm at about midvalve; costellae numbering 5-6 in 1 mm at about midvalve. Ventral interior with a pair of strong dental plates, converging anteriorly and fusing with high median septum; median septum extending to nearly midvalve. Dorsal interior with a pair of strong crural plates and short median septum.

Remarks.—*Geyerella ofunatoensis* sp. nov. most resembles *Geyerella mongolica* Grabau (1931, p. 267, pl. 26, figs. 1a-1d; text-figs. 67A-67C), from the Zhesi (Jisu) Formation of Zhesi, Inner Mongolia, North China, by its irregular strong concentric rugae on the ventral valve, but it differs from the Chinese species in having more numerous, finer costae on the both ventral and dorsal valves.

The type species *Geyerella gemmellaroi* Schellwien (1900a, p. 13, pl. 1, figs. 7a, 7b), from the Permian (?) of Sosio, differs from the present new species in lacking concentric rugae on the ventral valve.

Geyerella sp.
Figs. 5.7a-5.7c

Material.—One specimen, external and internal moulds of a ventral valve, NU-B1478.

Description.—Shell small for genus, deeply conical, nearly semicircular in outline; hinge straight, slightly shorter than greatest width at about midvalve; length about 13 mm, width about 14 mm, height about 15 mm. Ventral valve high, conical; umbo slightly bent; interarea long, broad, and flat in both transverse and longitudinal directions. External surface of ventral valve ornamented with irregular strong rugae, simple costae and numerous capillae; costae numbering 3-4 in 5 mm near anterior margin of valve. Ventral interior with a pair of strong dental plates converging on high median septum.

Remarks.—This specimen is safely assigned to the genus *Geyerella* by its high, conical ventral valve, with long and broad interarea, and distinct dental plates converging on high median septum. The Maeda species may be a new species, although they are poorly preserved. *Geyerella alpina* Schellwien, 1900a, redescribed by Schellwien (1900b, p. 25, pl. 3, figs. 6-13) as *Geyerella distorta* on the specimens from the Trogokofel Limestone of the Karavanke Mountains, Slovenia, differs from the present species in its narrower ventral interarea and more weak and sparse costae on the ventral valve.

The preceding new species, *Geyerella ofunatoensis,* differs from the present species by its much larger size and shallower cone-shaped ventral valve.

Two *Geyerella* species from the lower Kanokura Formation of the South Kitakami Belt, *Geyerella arakii* Hayasaka (1963, p. 481, figs. 2, 3) and *Geyerella koizumii* Hayasaka (1966, p. 1223, figs. 1-3) are clearly distinguished from the Maeda species by their high, elongate ventral valve, ornamented with strong and acute costae.

Family Schuchertellidae Williams, 1953
Subfamily Streptorhynchinae Stehli, 1954
Genus *Tropidelasma* Cooper and Grant, 1969

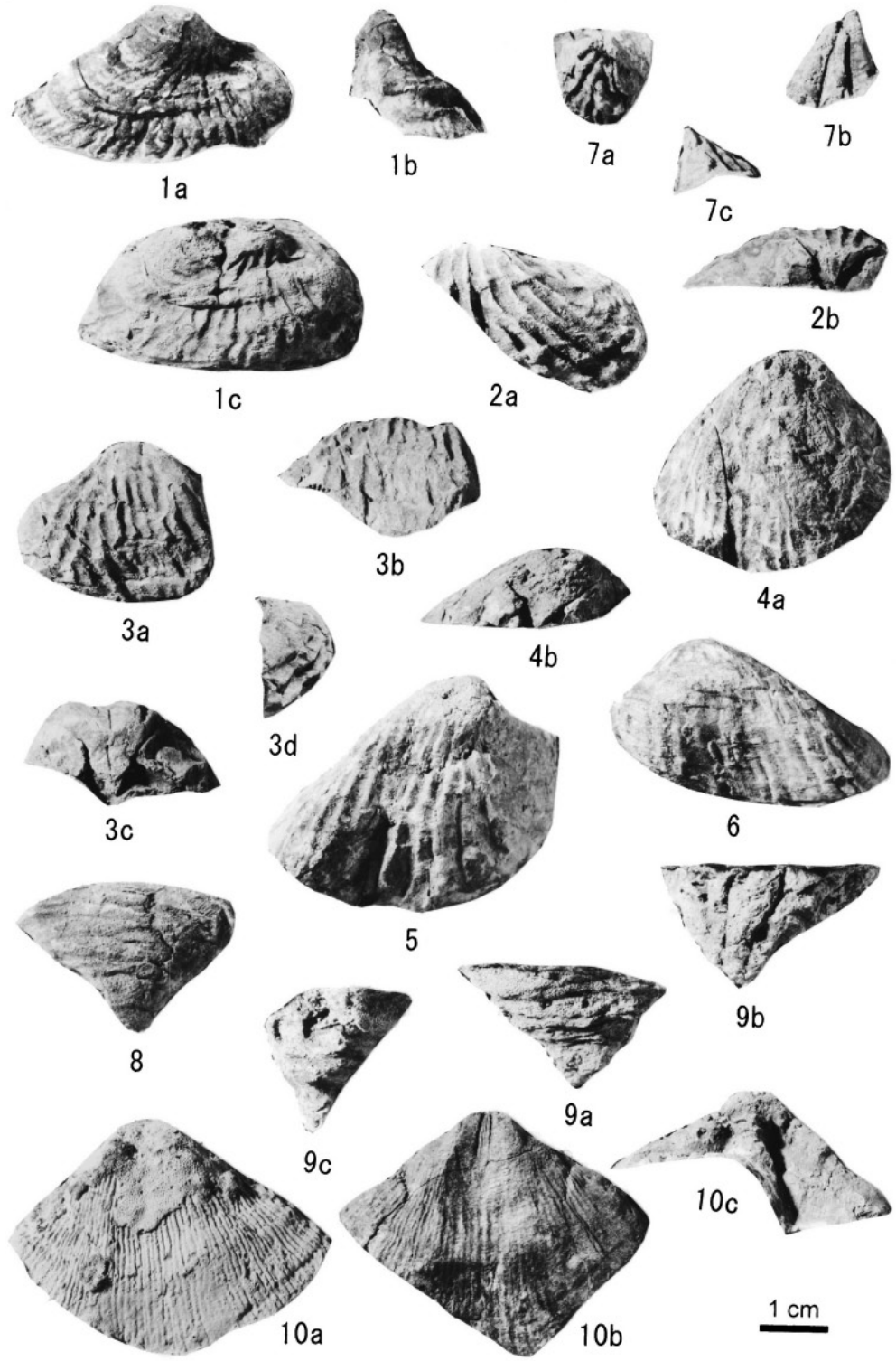
Type species.—*Tropidelasma culmenatum* Cooper and Grant, 1969.

Tropidelasma sp.
Figs. 5.8-5.9c

Material.—Three specimens: (1) external and internal moulds of a ventral valve, NU-B1480; (2) internal moulds of two ventral valves, NU-B1481, 1482.

Remarks.—These specimens can be assigned to the genus *Tropidelasma* by their deep, slightly bent, cone-shaped ventral valves, with long interarea, and ornamented with strong rugae and fine, numerous capillae.

The Maeda species most resembles *Tropidelasma anthicum* Cooper and Grant (1974, p. 335, pl. 59, figs. 1-36; pl. 60, figs. 1-39) from the Word Formation of West Texas in its anteriorly flared ventral valve, with narrow umbo, and strong, relatively sparse concentric rugae on the valve.


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

Tropidelasma yamasugensis Tazawa (in Tazawa et al., 2010, p. 39, figs. 3.2a-3.2e) from the Middle Permian (Murgabian or Wordian) Nabeyama Formation of Yamasuge, central Japan differs from the present species in its more numerous and less strong rugae on the ventral valve.

Order Orthida Schuchert and Cooper, 1932
Suborder Dalmanellidina Moore, 1952
Superfamily Enteletoidea Waagen, 1884
Family Enteletidae Waagen, 1884
Genus *Enteletes* Fischer de Waldheim, 1825

Type species.—*Enteletes glabra* Fischer de Waldheim, 1830.

Enteletes andrewsi Grabau, 1931
Figs. 3.7a-3.9

Enteletes andrewsi Grabau, 1931, p. 222, pl. 10, figs. 2-5; pl. 11, figs. 1a-2f; Jin, 1985, pl. 6, figs. 9-11; Duan and Li, 1985, p. 99, pl. 33, figs. 1-7; Wang and Zhang, 2003, p. 127, pl. 30, figs. 1-15; pl. 50, figs. 3, 8.

Enteletes obesa Grabau, 1931, p. 229, pl. 9, figs. 7a-7f; pl. 12, figs. 2-4; Duan and Li, 1985, p. 100, pl. 34, figs. 1-5.

Enteletes obesus Grabau: Licharew and Kotlyar, 1978, pl. 19, figs. 3a-3d.

Material.—Five specimens: (1) internal moulds of two ventral valves, NU-B1502, 1503; (2) external casts of two dorsal valves, NU-B1504, 1505; (3) internal mould of a dorsal valve, NU-B1506.

Description.—Shell medium size for genus, elongate suboval in outline, hinge shorter than greatest width at slightly anterior to midvalve; length 21 mm, width 18 mm in the best preserved dorsal valve specimen (NU-B1504). Ventral valve strongly convex in lateral profile; sulcus deep and broad, with V-shaped bottom. Dorsal valve also strongly convex in lateral profile,

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⬅ **Fig. 5.** 1a-6: *Geyerella ofunatoensis* sp. nov., 1a, 1b, 1c: ventral and lateral views of external latex cast, and internal mould of ventral valve, NU-B1487 (holotype), 2a, 2b: dorsal and posterior views of internal mould of dorsal valve, NU-B1491, 3a, 3b, 3c, 3d: ventral, anterior, posterior and lateral views of internal mould of dorsal valve, NU-B1492, 4a, 4b: dorsal and posterior views of internal mould of dorsal valve, NU-B1490, 5: internal mould of dorsal valve, NU-B1489, 6: external natural cast of dorsal valve, NU-B1488. 7a, 7b, 7c: *Geyerella* sp., ventral, posterior and lateral views of internal mould of ventral valve, NU-B1478. 8-9c: *Tropidelasma* sp., 8: anterior view of internal mould of ventral valve, NU-B1480, 9a, 9b, 9c: anterior, posterior and lateral views of internal mould of ventral valve, NU-B1481. 10a, 10b, 10c: *Choristitella wynnei* (Waagen), external latex cast, and ventral and posterior views of internal mould of ventral valve, NU-B1501.

with high, broad, subangular fold. External surface of both valves ornamented with some strong, subangular costae and numerous capillae; numbering 2-3 costae on one side of the flank; 6-7 capillae in 1 mm at about midlength of dorsal valve. Ventral interior with a pair of high, thin, subparallel dental plates, bisected by a high, thin median septum. Dorsal interior with a pair of strong, diverging brachiophores and a low, short median septum.

Remarks.—These specimens are poorly preserved, but they can be identified with *Enteletes andrewsi* Grabau, 1931, originally described from both of the *Enteletes* Bed and the *Martinia* Bed of the Jisu Honguer Limestone (Yiheusu Formation of Duan and Li, 1985) of Jisu (Zhesi), Inner Mongolia, North China, by their size, outline and external ornament of the shells, especially by the elongate outline, and in having a deep, V-shaped ventral sulcus and high, subangular dorsal fold. *Enteletes obesa* Grabau (1931, p. 229, pl. 9, figs. 7a-7f; pl. 12, figs. 2-4), from the Zhesi Formation of Inner Mongolia, is a junior synonym of *E. andrewsi* as noted by Wang and Zhang (2003, p. 127).

Enteletes gibbosus Chronic (1953, p. 92, pl. 16, figs. 9-14), from the Copacabana Group of Peru, and recorded also from the Lower and Middle Permian of Japan (Hayasaka and Kato, 1966; Yanagida and Hirata, 1969; Shen and Tazawa, 1998), is distinguished from *E. andrewsi* by its less transverse, rounded shell and more weak costae on the both valves.

Distribution.—Middle Permian (Roadian-Capitanian) of Northwest China (Qinghai), North China (Inner Mongolia); Upper Permian (Lopingian) of North Chia (Inner Mongolia), eastern Russia (South Primorye) and northeast Japan (Maeda in the South Kitakami Belt).

Family Schicophoriidae Schuchert and LeVene, 1929
Genus *Orthotichia* Hall and Clarke, 1892

Type species.—*Orthis*? *morganiana* Derby, 1874.

Orthotichia sp.
Figs. 2.2a, 2.2b

Material.—One specimen, external and internal moulds of a ventral valve, NU-B1500.

Remarks.—This specimen is safely assigned to the genus *Orthotichia* by its small, transversely subelliptical ventral valve (length 10 mm, width 18 mm), ornamented with numerous fine costellae and irregular concentric rugae, and in having a long median septum and a pair of strong dental plates in the valve.

Orthotichia sp. of Tazawa (2008c, p. 51, figs. 8.9a, 8.9b), from the Mizukoshi Formation (Lopingian) of Mizukoshi, central Kyushu, southwest Japan, differs from the Maeda species in its less transverse outline.

Orthotichia japonica Hayasaka, 1932, redescribed and figured by Hayasaka (1933, p. 20, pl. 3, figs. 1a, 1b; pl. 4, figs. 1a-2c; pl. 5, figs. a-d; pl. 6, fig. 1; text-fig. 3) and Tazawa et al.

(2010, p. 42, figs. 4.2a, 4.2b, 5.1a, 5.1b) from the Nabeyama Formation (Wordian) of Kuzu, Ashio Mountains, central Japan, is easily distinguished from the present species by its much larger size.

Order Athyridida Boucot, Johnson and Staton, 1964
Suborder Retziidina Boucot, Johnson and Staton, 1964
Superfamily Retzioidea Waagen, 1883
Family Neoretziidae Dagys, 1972
Subfamily Hustediinae Grunt, 1986
Genus *Hustedia* Hall and Clarke, 1893

Type species.—*Terebratula mormoni* Marcou, 1858.

Hustedia minuta Tazawa sp. nov.
Figs. 2.5, 2.6

Etymology.—Latin, *minuta*, small.

Material.—Three specimens: (1) external cast of a ventral valve, NU-B1472 (holotype); (2) internal mould of a ventral valve, NU-B1473; (3) internal mould of a dorsal valve, NU-B1474.

Diagnosis.—Small *Hustedia*, having 12 rounded costae with broad and flat intercostal furrows on ventral valve.

Description.—Shell small for genus, suboval in outline, with greatest width slightly posterior to midvalve; length about 5 mm, width about 4 mm in the holotype (NU-B1472). Ventral valve moderately convex in lateral profile, having no sulcus. Dorsal valve also moderately convex, no fold. External surface of both valves ornamented by rounded costae, with wider and flat-bottomed intercostal furrows; numbering 12 costae on ventral valve. Internal structure of both valves obscure.

Remarks.—*Hustedia minuta* sp. nov. most resembles *Hustedia remota* (Eichwald, 1860), redescribed by Tschernyschew (1902, p. 107, pl. 47, figs. 8-11) from the *Schwagerina* Limestone (Asselian) of Ufa, southern Urals, in having wide and flat intercostal spaces, but differs in its much smaller size.

Hustedia episkopiensis Shen and Clapham (2009, p. 728, pl. 4, figs. 17-24), from the upper Episkopi Formation (Wuchiapingian) of Hydra Island, Greece, is also a small-sized species, but it differs from the present new species in having more numerous costae, with narrower intercostal spaces.

Order Spiriferida Waagen, 1883
Suborder Spiriferidina Waagen, 1883

Superfamily Ambocoelioidea George, 1931
Family Ambocoeliidae George, 1931
Subfamily Ambocoeliinae George, 1931
Genus *Attenuatella* Stehli, 1954

Type species.—*Attenuatella texana* Stehli, 1954.

Attenuatella sp.
Fig. 2.8

Material.—One specimen, internal mould of a ventral valve, NU-B1475.

Description.—Shell large for genus, elongate oval in outline, with greatest width at slightly anterior to midvalve; length about 17 mm, width about 13 mm. Ventral valve strongly convex in lateral profile; umbo narrow and incurved; lateral slopes steep. Interior of ventral valve with a long median ridge, on which muscle scars sited; median ridge occupying posterior three-quarters of valve length, separated by a narrow median groove, and tapering anteriorly.

Remarks.—This specimen somewhat resembles *Attenuatella bandoi* Tazawa (1987, p. 281, figs. 3, 4) from the lower Toyoma Formation (Wuchiapingian) of Ishihama in the Utatsu area, South Kitakami Belt, but it differs from the Utatsu species in its more transverse outline and larger dimensions.

Atenuatella sp., described by Angiolini (2001, p. 327, pl. 2, figs. 2-3, 27) from the Middle Permian (Wordian) of the Karakorum, northern Pakistan, is also a large-sized species, but it differs from *A. bandoi* by its much larger size.

Superfamily Spiriferoidea King, 1846
Family Choristitidae Waterhouse, 1968
Subfamily Choristitinae Waterhouse, 1968
Genus *Choristitella* Ivanov and Ivanova, 1937

Type species.—*Choristites podolskensis* Ivanov and Ivanova, 1937.

Choristitella wynnei (Waagen, 1883)
Figs. 5.10a-5.10c

Spirifer wynnei Waagen, 1883, p. 517, pl. 44, figs. 6a-7; Licharew and Kotlyar, 1978, pl. 21, fig. 14.
Choristitella wynnei (Waagen): Kotlyar in Kotlyar et al., 1989, pl. 24, figs. 4-5b.

Material.—One specimen, external and internal moulds of a ventral valve, NU-B1501.

Description.—Shell large for genus, transversely subelliptical in outline; hinge shorter than greatest width at about midvalve; length about 35 mm or more, width about 50 mm or more, hinge width about 45 mm in the single ventral valve specimen (NU-B1501). Ventral valve moderately convex in lateral profile, most convex at posterior region; cardinal extremities rounded; interarea high, triangular, slightly concave in cross section; sulcus shallow and broad, originating just anterior to umbo, and widening towards anterior. External surface of ventral valve ornamented with numerous fine costae with narrow intercostal furrows and a few irregular concentric rugae; costae often bifurcating, numbering 5-6 in 5 mm at about midvalve. Ventral interior with a pair of short (about 8 mm long), close set, subparallel dental adminicula. Other internal structures obscure.

Remarks.—This specimen is referred to *Choristitella wynnei* (Waagen, 1883), originally described from the Wargal Formation of the Salt Range, by its large, transverse ventral valve and the external ornament consisting of numerous costae, with a density of 5-6 in 5 mm at about midvalve.

The type species *Choristitella podolkensis* (Ivanov and Ivanova, 1937, p. 170, 196, pl. 15, figs. 2-5; pl. 23, figs. 3-4b; text-fig. 55), from the upper Moscovian of the Moscow Basin, differs from *Choristitella wynnei* in its smaller size, less transverse outline, and in having deeper and narrower sulcus on the ventral valve.

Distribution.—Middle Permian (Capitanian)-Upper Permian (Wuchiapingian) of the Salt Range, Pakistan; Upper Permian (Wuchiapingian) of South Primorye, eastern Russia; Upper Permian (Changhsingian) of the South Kitakami Belt, northeast Japan.

Suborder Spiriferinidina Ivanova, 1972
Superfamily Pennospiriferinoidea Dagys, 1972
Family Paraspiriferinidae Cooper and Grant, 1976
Genus *Callispirina* Cooper and Muir-Wood, 1951

Type species.—*Spiriferina ornata* Waagen, 1883.

Callispirina sp.
Figs. 2.3, 2.4

Material.—Three specimens: (1) external moulds of two ventral valves, NU-B1483, 1484; (2) internal mould of a ventral valve, NU-B1485.

Remarks.—These specimens are safely assigned to the genus *Callispirina* by their small, nearly equidimensional shell (length about 9 mm, width about 11 mm or more in the better preserved specimen, NU-B1483), having a deep sulcus with V-shaped bottom in the ventral valve, and 3 simple, strong, angular costae on each side of the sulcus, and numerous, closely

spaced growth lines over the ventral valve. Ventral interior with a thin but high median septum, extending for midlength of the valve.

The type species, *Callispirina ornata* (Waagen, 1883, p. 505, pl. 50, figs. 1a-2), from the Chhidru Formation of the Salt Range, differs from the present species in its much larger size.

Callispirina austrina Grant (1976, p. 231, pl. 63, figs. 1-37), from the Rat Buri Limestone of Ko Muk, southern Thailand, is similar in size, but the Thai species has more numerous, less angular costae in the ventral valve.

Callispirina? *rotundella* Xu and Grant (1994, p. 47, figs. 36.24-36.30), from the Changhsingian of Zheziang and Sichuan, South China, is also a small-sized species, but the Chinese species differs from the Kitakami species in having more numerous costae in the ventral valve.

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