

***Linoprotonia* and *Gigantoproductus* (Linoproductoidea, Brachiopoda)
from the Lower Carboniferous in the Onimaru quarry, Hikoroichi,
southern Kitakami Mountains, NE Japan**

Jun-ichi TAZAWA* and Yousuke IBARAKI**

Abstract

Four species of linoproductoid brachiopods, *Linoprotonia ashfellensis* Ferguson, 1971, *Linoprotonia hikoroichiensis* sp. nov., *Gigantoproductus* cf. *crassiventer* (Prentice, 1949) and *Gigantoproductus* cf. *latiexpansus* Sarytcheva in Sarytcheva and Sokolskaya, 1952, are described from the upper Lower Hikoroichi Formation in the Onimaru quarry, Hikoroichi, southern Kitakami Mountains, northeast Japan. The age of the fossil horizon is assigned to be Early Visean on the basis of the occurrence of *Linoprotonia ashfellensis*, an Early Visean species from northern England.

Key words: Brachiopoda, Early Visean, *Gigantoproductus*, Hikoroichi Formation, *Linoprotonia*, Onimaru quarry, southern Kitakami Mountains

Introduction

The Onimaru quarry in the Hikoroichi area, southern Kitakami Mountains, northeast Japan is a famous fossil locality of Early Carboniferous marine invertebrates, such as corals, bryozoans, brachiopods, gastropods, cephalopods and trilobites, and also land plants (Ofunato City Museum, 1989). In the quarry, these fossils occur from grey to greenish grey fine-grained sandstone and dark grey sandy shale of the upper part of the lower Hikoroichi Formation (H₂ Member of Kawamura, 1983; HK2 Member of Tazawa, 1985). The fossils are important for establishing the biostratigraphy and correlation of the Hikoroichi Formation, although most of the specimens remain undescribed.

Tazawa (1984, 1985, 1989, 2006) described or figured the following eight brachiopod

* Department of Geology, Faculty of Science, Niigata University, Niigata 950-2181, Japan

** Fossa Magna Museum, Ichinomiya 1313, Itoigawa 941-0056, Japan

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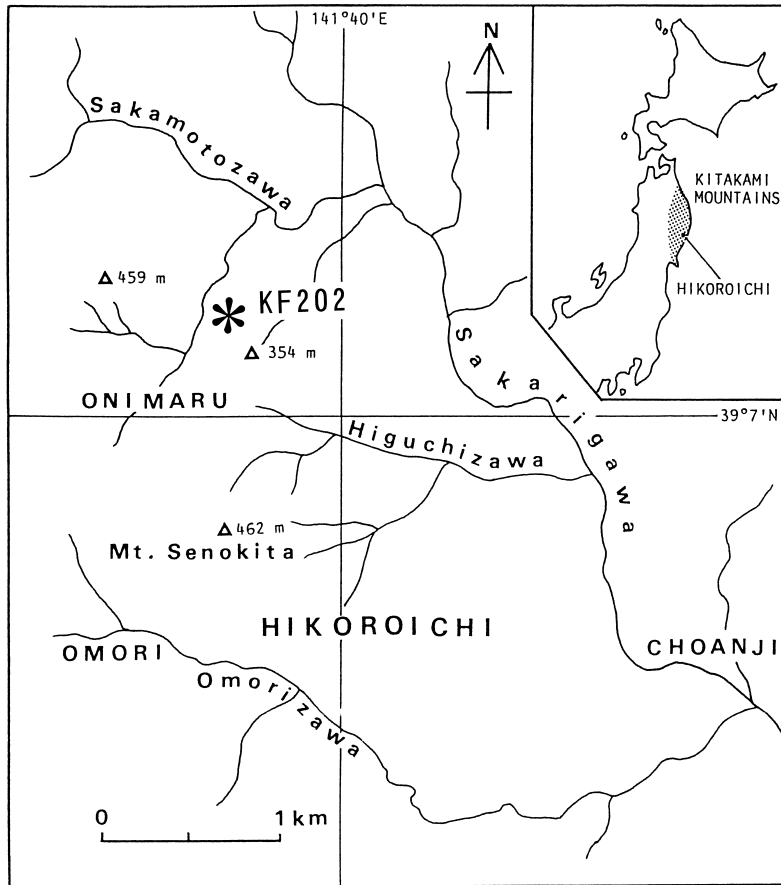


Fig. 1. Index map showing the fossil locality KF202 in the Hikoroichi area, southern Kitakami Mountains (adapted from Tazawa, 1984).

species from the sandstone and shale of the upper Lower Hikoroichi Formation, cropped out at the Onimaru quarry: *Gigantoproductus* sp. A, *Gigantoproductus* sp. B, *Linoprotonia* sp., *Buxtonia* sp., *Unispirifer* sp., *Lamellosathyris lamellosa* (Léveillé, 1835), *Marginatia burlingtonensis* (Hall, 1858) and *Rotaia hikoroichiensis* Tazawa, 2006. The first three species are revised and redescribed in this paper as *Linoprotonia ashfellensis* Ferguson, 1971, *Linoprotonia hikoroichiensis* sp. nov. and *Gigantoproductus* cf. *latiexpansus* Sarytcheva in Sarytcheva and Sokolskaya, 1952. Furthermore, a gigantoproductid species is described as *Gigantoproductus* cf. *crassiventer* (Prentice, 1949) based on new material.

The brachiopod specimens treated in this paper were collected by the first author (JT) from locality KF202 (39°7'28" N, 141°39'23" E) within the Onimaru quarry (Figs. 1-3). We consider the age of the fossil horizon is an Early Visean on the basis of the occurrence of *Linoprotonia ashfellensis*, described by Ferguson (1971) from the Lower Visean (S₂ Zone) of Westmorland,

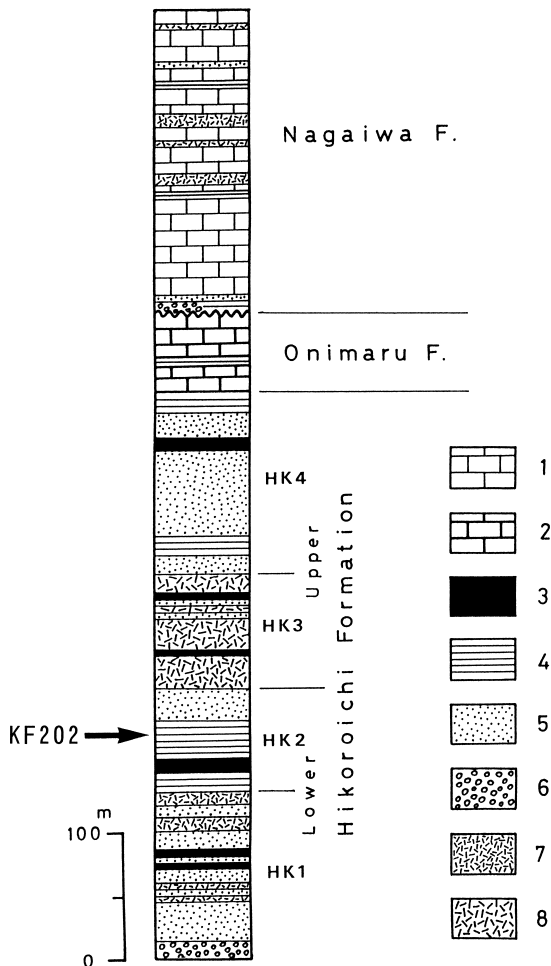


Fig. 2. Generalized columnar section of the Carboniferous formations of the Hikoichi area, southern Kitakami Mountains, showing the fossil horizon KF202 (modified and adapted from Tazawa, 1984).

Northwest England. This estimation accords with previous opinion, an Early Viséan, based on corals (Kawamura, 1983) and brachiopods (Tazawa, 1985, 2006).

All described specimens are registered and housed in the Department of Geology, Faculty of Science, Niigata University.

Systematic descriptions

The supra-generic classification of the Productida follows Waterhouse (2002).

Order Productida Sarytcheva and Sokolskaya, 1959

Suborder Productidina Waagen, 1883

Superfamily Linoproductoidea Stehli, 1954

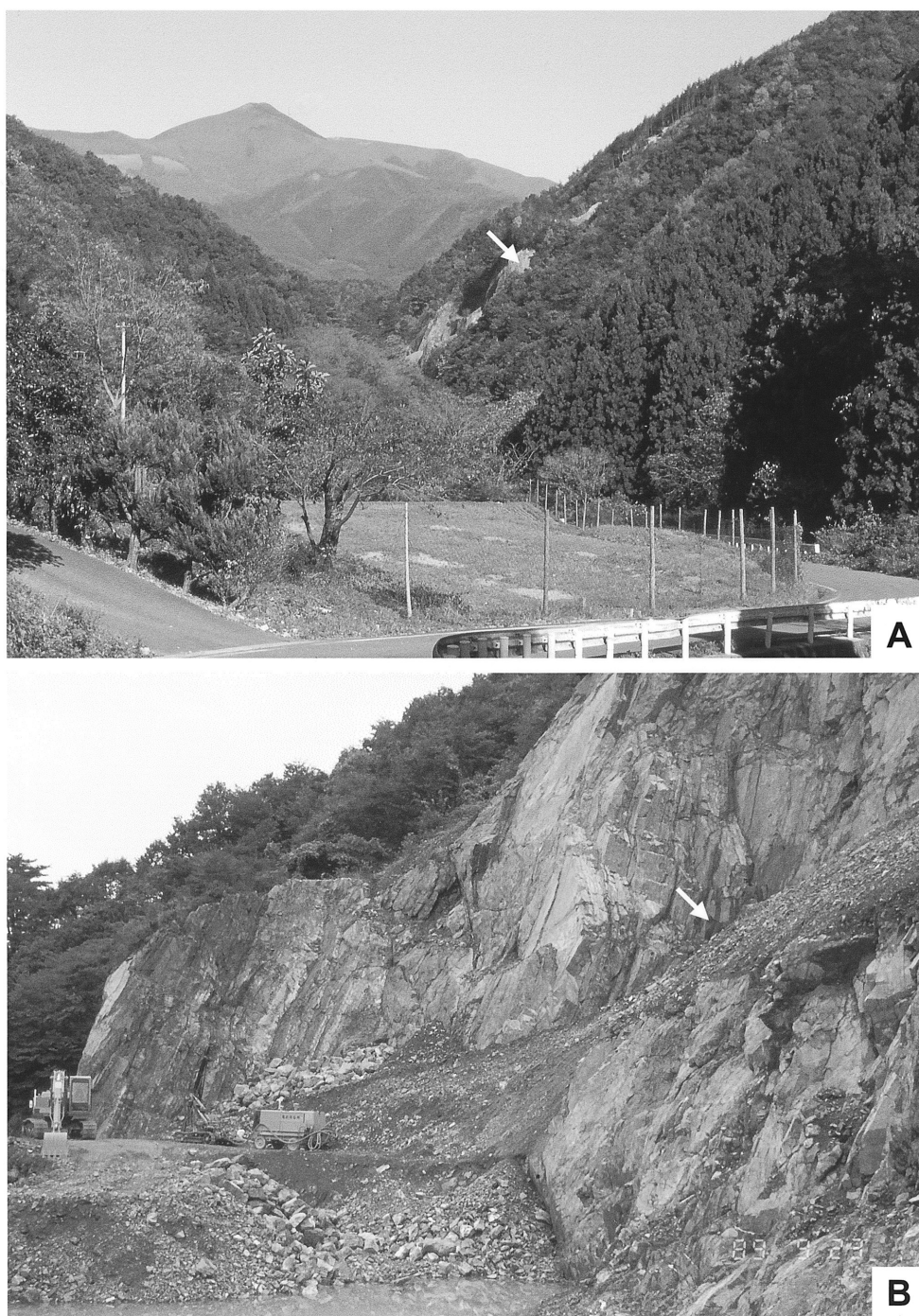


Fig. 3. A distant view (A) and a close view (B) of the outcrop of sandstone and shale of the upper Lower Hikoroichi Formation in the Onimaru quarry, Hikoroichi-cho, Ofunato City, Iwate Prefecture. Arrows show the fossil locality (KF202). Mt. Goyosan in the background is composed of Cretaceous granitic rocks.

Family Linoproductidae Stehli, 1954
Subfamily Linoproductinae Stehli, 1954
Tribe Linoproductini Stehli, 1954
Genus *Linoprotonia* Ferguson, 1971

Type species.—*Productus hemisphaericus* Sowerby, 1822 in 1821-1822.

Linoprotonia ashfellensis Ferguson, 1971
Figs. 4.1a-4.3

Linoprotonia ashfellensis Ferguson, 1971, p. 558, pl. 42, figs. 1-7; text-fig. 2A; Pattison, 1981, p. 11, pl. 1, figs. 1, 2; pl. 7, fig. 2; pl. 9, fig. 12.

Gigantoproductus sp. B Tazawa, 1984, p. 58, pl. 1, figs. 4a-5 only.

Linoprotonia sp. Tazawa, 1989, p. 61, pl. 1, fig. 5 only.

Material.—Six specimens: (1) external and internal moulds of a ventral valve, NU-B597; (2) internal moulds of five ventral valves, NU-B598-602.

Description.—Shell medium size for genus, transversely semicircular in outline, with greatest width at midvalve; length 42 mm, width 64 mm in the best preserved ventral valve specimen (NU-B597). Ventral valve strongly convex at umbonal region, with flattened venter, strongly geniculated at anterior margin, and followed by short trail; lateral slopes steep; umbo small; ears small, rounded, and ill-defined; sulcus absent. External ornament of ventral valve consisting of numerous costae and weak concentric rugae; costae often bifurcating or intercalating, and having a density of 12-13 per 10 mm at about midvalve; rugae irregularly developed on anterior portion of valve. Ventral valve interior with broad, oval and dendritic adductor scars, and large, flabellate diductor scars; the latter consisting of trigonal, smooth posterior portion and broad, finely striated anterior portion.

Remarks.—The specimens from the Onimaru quarry were erroneously referred to the genus *Gigantoproductus* Prentice, 1950 in the previous study (Tazawa, 1984), but they are here assigned to the genus *Linoprotonia* Ferguson, 1971 on the basis of their linoproductid external feature and gigantoproductid internal structure. These specimens are referred to *Linoprotonia ashfellensis* Ferguson, 1971, from the Lower Visean (S₂ Zone) of Westmorland, Northwest England, in having small ears and flattened venter in the ventral valve.

The differences between *Linoprotonia ashfellensis* and other *Linoprotonia* species from northern England, *Linoprotonia hemisphaerica* (Sowerby, 1822) and *Linoprotonia corrugatohemispherica* (Vaughan in Dixon and Vaughan, 1911), were fully discussed by Ferguson (1971, p. 559).

Linoprotonia hikorochiensis sp. nov.

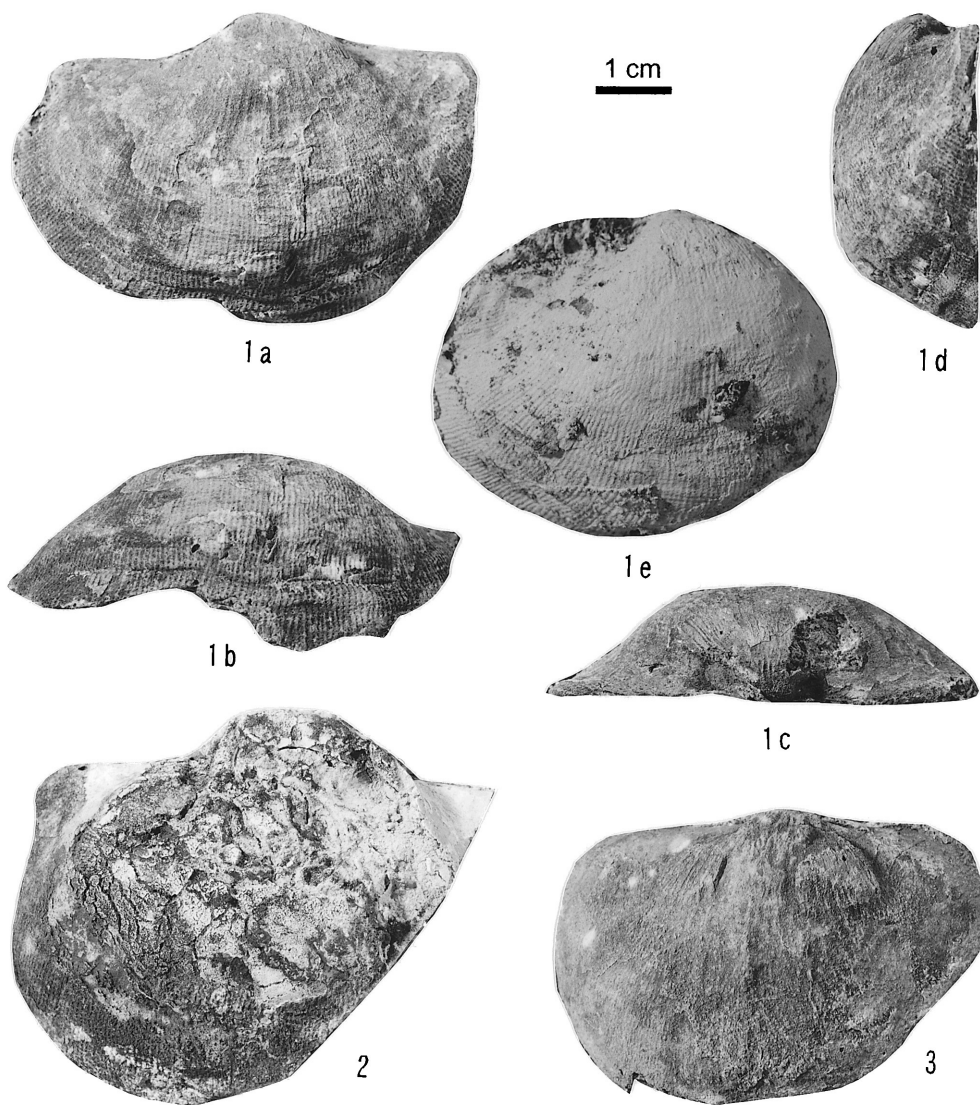


Fig. 4. *Linoprotonia ashfellensis* Ferguson, from the upper part of the lower Hikoroichi Formation in the Onimaru quarry (KF202). 1a, 1b, 1c, 1d, 1e: ventral, anterior, posterior and lateral views of internal mould of ventral valve, and external latex cast of ventral valve, NU-B597, 2: internal mould of ventral valve, NU-B602, 3: internal mould of ventral valve, NU-B598.

Figs. 5.1a-5.5b

Etymology.—Fossil locality Hikoroichi-cho, Ofunato City, Iwate Prefecture.

Gigantoproductus sp. B Tazawa, 1984, p. 58, pl. 1, figs. 2, 3 only.

Material.—Eighteen specimens: (1) external and internal moulds of three ventral valves, NU-B603 (holotype)-605; (2) external moulds of two ventral valves, NU-B606, 607; (3) internal moulds of seven ventral valves, NU-B608-614; (4) external and internal moulds of a dorsal valve, NU-B615; (4) external moulds of five dorsal valves, NU-B616-620.

Diagnosis.—Medium-sized, transverse *Linoprotonia*, having gently convex ventral valve, with large, prominent ears, and fine costae, numbering 14-16 in 10 mm at midvalve.

Description.—Shell medium size for genus, transversely semicircular to subquadrate in outline, with greatest width at hinge; length 33 mm, width 63 mm in the holotype (NU-B603); length 36 mm, width 65 mm in the largest ventral valve specimen (NU-B608).

Ventral valve gently convex in both lateral and anterior profiles, most convex at umbonal region; umbo small; ears large, prominent, but not clearly differentiated from venter; sulcus absent. External ornament of ventral valve consisting of numerous costae, numbering 14-16 in 10 mm at midvalve; rugae very rare near anterior margin; spines visible on hinge line just posterior to ears (see Fig. 5.5b). Interior of ventral valve with broad, oval and dendritic adductor scars and large, flabellate diductor scars; the latter consisting of trigonal, smooth posterior portion and broad, finely striated anterior portion.

Dorsal valve gently concave in both lateral and anterior profiles, with rather flattened venter; umbo small; ears large; fold absent. External ornament of dorsal valve same as the opposite valve; costae numbering 16-18 in 10 mm at about midvalve; concentric rugae developed on venter; spines or spine bases not observed. Interior of dorsal valve, with a thin, long median septum, extending to midvalve. Other internal structures are not well preserved.

Remarks.—*Linoprotonia hikoroichiensis* sp. nov. can be differentiated from the above described species, *Linoprotonia ashfellensis* Ferguson, 1971, by its less convex ventral valve, much larger, prominent ears, and finer costae on the ventral valve.

The type species, *Linoprotonia hemispherica* (Sowerby, 1822, pl. 328, figs. a-d), from the Upper Viséan of South Wales, differs from the present new species by its smaller dimensions and finer costae on the ventral valve.

Subfamily Gigantoproductinae Muir-Wood and Cooper, 1960

Tribe Gigantoproductini Muir-Wood and Cooper, 1960

Genus *Gigantoproductus* Prentice, 1950

Type species.—*Anomites giganteus* Martin, 1793.

Gigantoproductus cf. *crassiventer* (Prentice, 1949)

Figs. 6.1a-6.2b

Compare.—

Gigantella crassiventer Prentice, 1949, p. 257, pl. 11, figs. 1a-1c; pl. 12, figs. 1a, 1b; pl. 13,

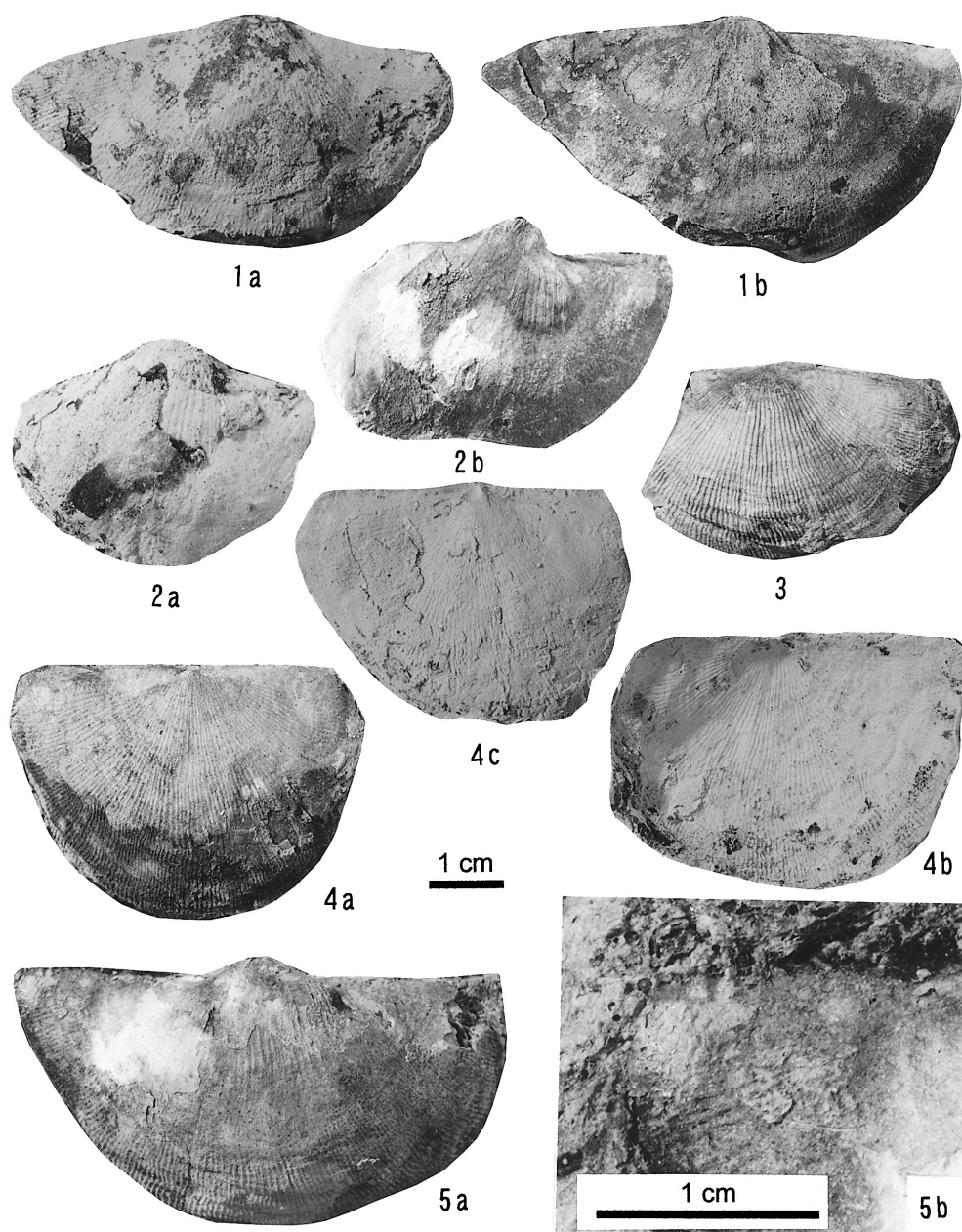


Fig. 5. *Linoprotonia hikoroichiensis* sp. nov., from the upper part of the lower Hikoroichi Formation in the Onimaru quarry (KF202). 1a, 1b: external latex cast and internal mould of ventral valve, NU-B603 (holotype), 2a, 2b: external latex cast and internal mould of ventral valve, NU-B604, 3: external mould of dorsal valve, NU-B616, 4a, 4b, 4c: external mould, external latex cast and internal latex cast of dorsal valve, NU-B615, 5a, 5b: internal mould of ventral valve, NU-B608.

figs. 1-7.

Gigantoproductus cf. *crassiventer* (Prentice): von Bitter and Legrand-Blain, 2007, p. 193, figs. 2B-2F.

Material.— Three specimens: (1) external and internal moulds of a ventral valve, NU-B621; (2) internal moulds of two ventral valves, NU-B622, 623.

Description.— Shell small to medium size for genus, elongate subquadrate in outline, with greatest width at slightly anterior to midvalve; length about 62 mm, width about 56 mm in the smaller but better preserved ventral valve specimen (NU-B622). Ventral valve strongly convex at umbonal region, gradually decrease curvature towards front; lateral slopes steep; umbo large, inflated, and strongly incurved over hinge; ears small, slightly convex, and well demarcated from venter; sulcus broad and very shallow. External surface of ventral valve ornamented with numerous costae, numbering 12-13 in 10 mm at about midvalve; ribbing weakly and irregularly developed on anterior half of valve; both of concentric rugae and spine bases not observed. Interior of ventral valve with a pair of highly elevated, elongate and faintly dendritic adductor scars, and large, flabellate diductor scars; the latter subdivided into two parts, trigonal-shaped, smooth posterior portion and finely striated anterior portion.

Remarks.—These specimens are closely allied to *Gigantoproductus crassiventer* (Prentice, 1949) from the Upper Visean of Staffordshire and Derbyshire, Central England, and also *Gigantoproductus* cf. *crassiventer* (Prentice), described by von Bitter and Legrand-Blain (2007) from the Upper Visean of Nova Scotia, eastern Canada, in size, shape and external ornament of the ventral valve. But the accurate comparison is difficult for poorly preserved specimens.

Gigantoproductus elongatus (Sarytcheva, 1928, p. 27, pl. 3, figs. 4a, 4b), from the Upper Visean of the Moscow Basin, differs from the Kitakami species by its more inflated ventral valve, having no sulcus and more strongly developed ribbing on venter and trail.

Gigantoproductus cf. *okensis* (Sarytcheva, 1928), described by Tazawa and Miyake (2002, p. 3, figs. 2, 3) from the Onimaru Formation (Upper Visean) of the Okusakamotozawa area, southern Kitakami Mountains, is easily distinguished from the present species by its much larger size and in having weak ribbing on the ventral valve.

Gigantoproductus cf. *latiexpansus* Sarytcheva

in Sarytcheva and Sokolskaya, 1952

Figs. 7.1a-7.1e

Gigantoproductus sp. A Tazawa, 1984, p. 58, pl. 1, figs. 1a-1d.

Linoprotonia sp. Tazawa, 1989, p. 61, pl. 1, figs. 4a-4d only.

Compare.—

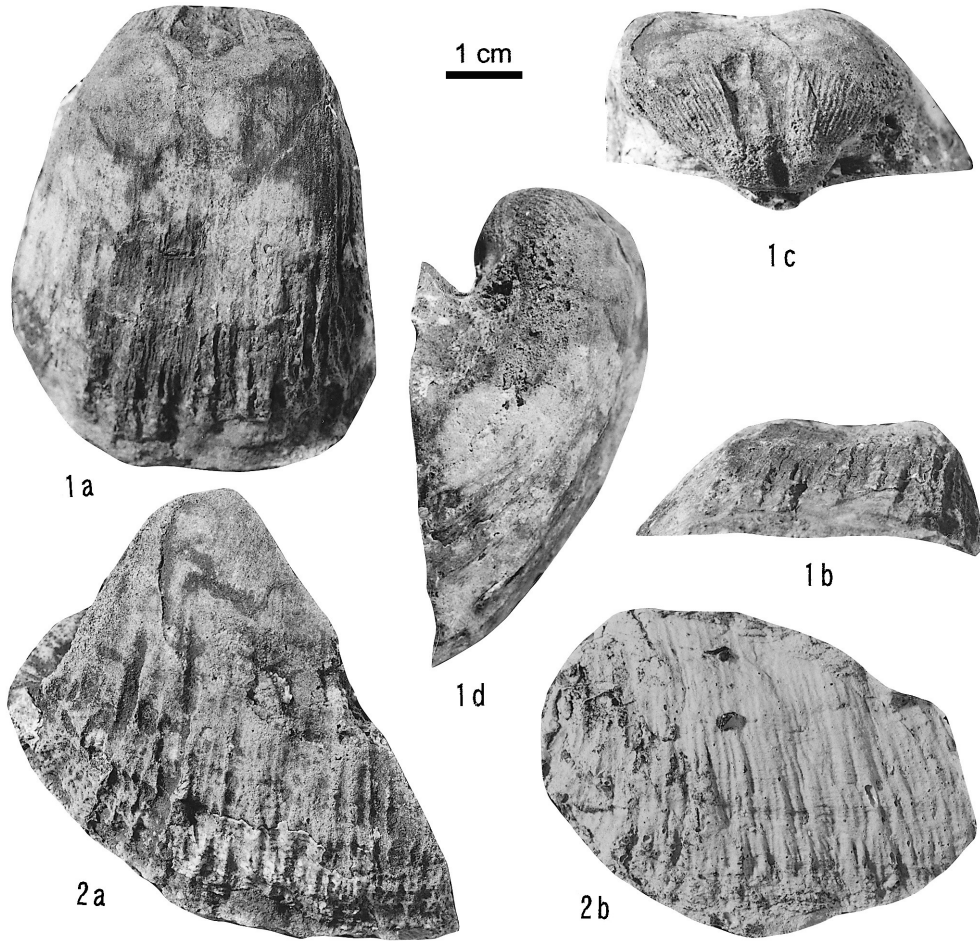


Fig. 6. *Gigantoproductus* cf. *crassiventer* (Prentice), from the upper part of the lower Hikoroichi Formation in the Onimaru quarry (KF202). 1a, 1b, 1c, 1d, 1e: ventral, anterior, posterior and lateral views of internal mould of ventral valve, NU-B622, 2a, 2b: internal mould and external latex cast of ventral valve, NU-B621.

Gigantoproductus latiexpansus Sarytcheva in Sarytcheva and Sokolskaya, 1952, p. 130, pl. 33, fig. 176.

Material.— Three specimens: (1) external and internal moulds of a ventral valve, NU-B624; (2) external moulds of two ventral valves, NU-B625, 626.

Description.— Shell small for genus, transversely semicircular in outline, with greatest width at about midvalve; length 43 mm, width 72 mm in the best preserved specimen (NU-B624). Ventral valve moderately and unevenly convex in lateral profile; most convex at umbonal

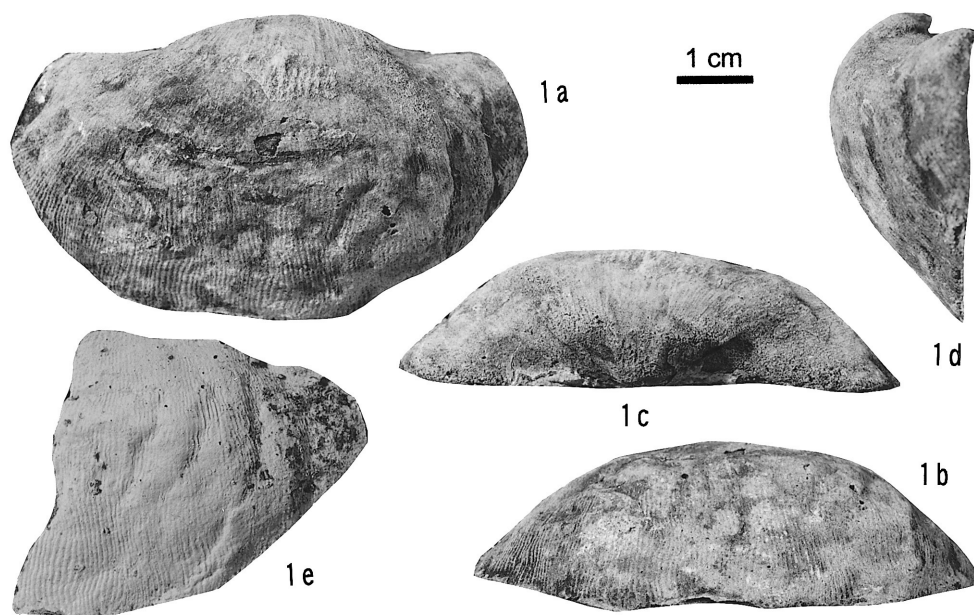


Fig. 7. *Gigantoproductus* cf. *latiexpansus* Sarytcheva, from the upper part of the lower Hikoroichi Formation in the Onimaru quarry (KF202). 1a, 1b, 1c, 1d, 1e: ventral, anterior, posterior and lateral views of internal mould of ventral valve, and external latex cast of ventral valve, NU-B624.

region, weakly convex at venter, and gradually flattened towards anterior margin; umbo large and broad, strongly incurved over hinge; ears small, rounded, not clearly demarcated from venter; sulcus absent. External surface of ventral valve ornamented with numerous, slightly flexuous costae, often bifurcating or intercalating, and having a density of 16-19 in 10 mm at about midvalve; ribbing irregular on both venter and lateral slopes; spines or spine bases not observed. Interior of ventral valve with a pair of broad, oval and dendritic adductor scars and very large, flabellate diductor scars; the latter consisting of trigonal, smooth posterior portion and broad, finely striated anterior portion.

Remarks.—The best preserved specimen (NU-B624) from the Onimaru quarry was figured by Tazawa (1984) as *Gigantoproductus* sp. A, and subsequently described by Tazawa (1989) as *Linoprotonia* sp. However, this specimen can be assigned to the genus *Gigantoproductus* by its strongly incurved umbo, slightly flexuous costae and irregular ribbing on the ventral valve. Recently two specimens, incomplete external moulds of two ventral valves (NU-B625, 626), were added to our material. The Hikoroichi species resembles *Gigantoproductus latiexpansus* Sarytcheva in Sarytcheva and Sokolskaya (1952), from the Upper Viséan and Serpukhovian of the Moscow Basin, in its transverse outline, ill defined

ears and irregular ribbing on the ventral valve, although the size of the ventral valve is smaller than the Russian species.

Gigantoproductus uniformis Morozov (1988, p. 32, pl. 2, figs. 1-5) from the Upper Visean of the Moscow Basin is somewhat similar in shell outline and irregular ribbing on the ventral valve, but the Russian species differs from the present species by its larger dimensions and coarser costae on the ventral valve.

The above-described species, *Gigantoproductus* cf. *crassiventer* (Prentice, 1949) from the Onimaru quarry, is clearly distinguished from the present species by its elongate shell, with coarser costae and irregular ribbing on the ventral valve.

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