

## A Lower Permian mixed Boreal-Tethyan brachiopod fauna from the Nagaiwa-Sakamotozawa area, South Kitakami Belt, NE Japan

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### Abstract

Three brachiopod species are described for the first time from the lowest part of the Sakamotozawa Formation (Sakmarian) of the Nagaiwa-Sakamotozawa area, South Kitakami Belt, northeast Japan. The specimens include two Boreal-type species, *Waagenoconcha humboldti* (d'Orbigny) and *Rhynchopora* sp., and a Tethyan-type species, *Scacchinella* sp. The occurrence of a mixed Boreal-Tethyan brachiopod fauna from the Lower Permian of the South Kitakami Belt suggests that the South Kitakami region was part of a continental shelf bordering the eastern margin of North China (Sino-Korea) during the Early Permian.

*Key words:* brachiopod, Lower Permian, mixed Boreal-Tethyan fauna, Nagaiwa-Sakamotozawa area, South Kitakami Belt.

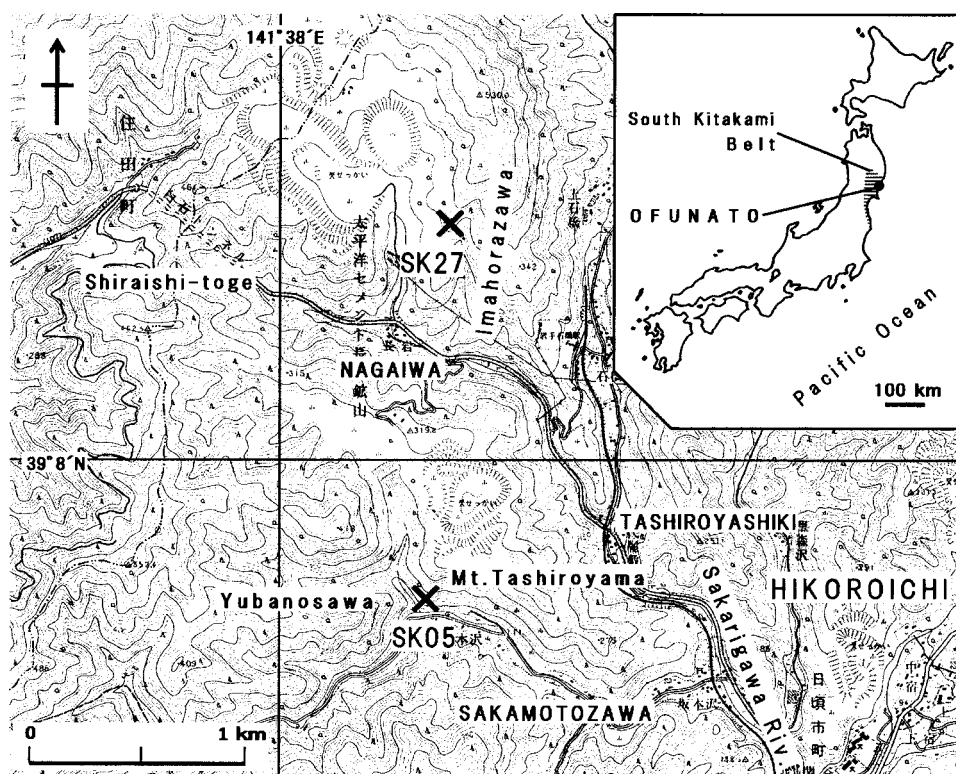
### Introduction

The Lower Permian brachiopod fauna from the South Kitakami Belt, northeast Japan, is poorly documented compared with those of the Middle and Upper Permian. Only 20 species in 14 genera have been described to date, in studies performed by Nakamura (1959, 1960, 1972) and Tazawa (1974) on the Lower Permian Sakamotozawa Formation in the Yahagi (Yukisawa), Nakadaira and Kamiyasse areas in the South Kitakami Belt. Recently Shintani (2009) reported a rich brachiopod fauna (40 species in 26 genera) from the lowest part of the Sakamotozawa Formation in the Nagaiwa-Sakamotozawa area, the type area of the formation, although these species remained undescribed.

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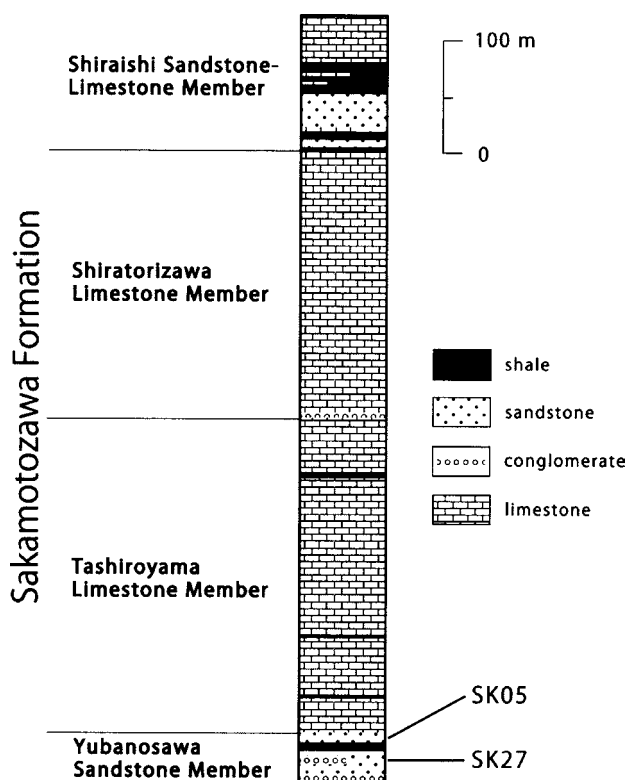


**Fig. 1.** Map showing the fossil localities SK05 and SK27, in the Nagaiwa-Sakamotozawa area (using the topographical map of “Sakari” scale 1:25,000 published by the Geographical Survey Institute of Japan).

The purpose of the present paper is to describe three brachiopod species within the Nagaiwa-Sakamotozawa fauna, and to discuss their palaeobiogeographical and palaeogeographical implications. The brachiopod specimens treated in this study are registered and housed in the Department of Geology, Faculty of Science, Niigata University, Niigata, Japan.

### Stratigraphy

The brachiopod fossils were collected by the second author of the present paper (TS) from sandstone within the lowest part (Yubanosawa Sandstone Member) of the Sakamotozawa Formation, at localities SK05 and SK27 in the Nagaiwa-Sakamotozawa area, Hikoroiichi-cho, Ofunato City, Iwate Prefecture, viz., the southern Kitakami Mountains, northeast Japan (Figs. 1, 2). At locality SK27, the sandstone contains fusulinids and brachiopods. In an analysis of



**Fig. 2.** Generalized columnar section of the Sakamotozawa Formation in the Nagaiwa-Sakamotozawa area, showing the fossil horizons, SK05 and SK27.

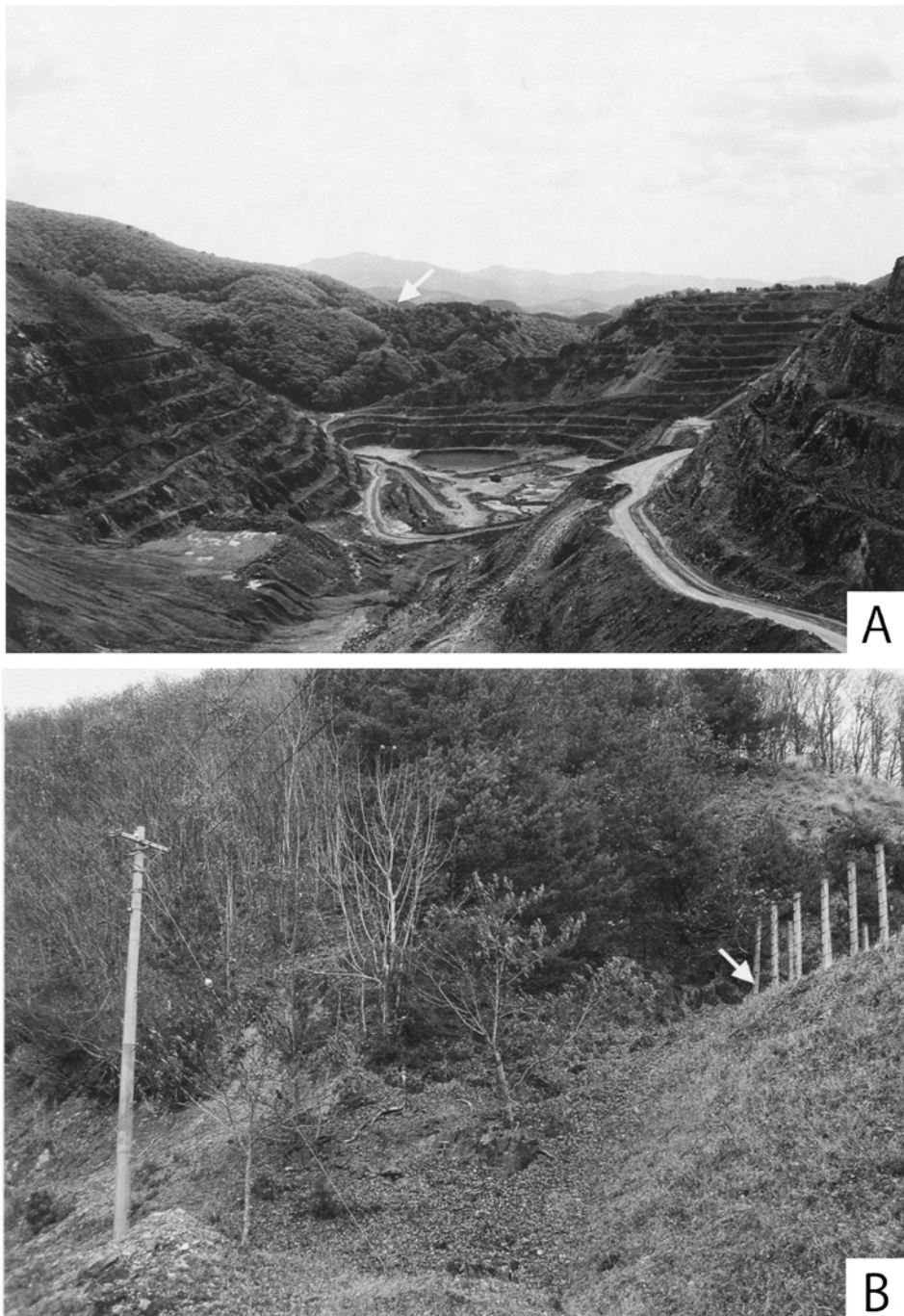
this site, Ueno et al. (2007) described the following fusulinid species: *Schubertella* sp., *Quasifusulina?* sp., *Rugosofusulina* sp., *Eoparafusulina* aff. *perplexa* (Grozdilova and Lebedeva) and *Nipponitella explicata* Hanzawa, assigning a Sakmarian age on this basis.

SK05: Grey to light brown medium-grained sandstone, 39 m above the base of the Sakamotozawa Formation, exposed at the mouth of the Yubanosawa Valley, Sakamotozawa (Lat. 39°8'6"N, Long. 141°38'51"E), with *Rhynchopora* sp.

SK27: (Figs. 3A, 3B) Dark-grey to grey sandy shale and grey fine-grained sandstone, 20 m above the base of the Sakamotozawa Formation, exposed in the upper part of the stream within the Imahorazawa Valley, approximately 690 m NNE of the junction between the Sakarigawa River and the Imahorazawa Valley, Nagaiwa (Lat. 39°9'9"N, Long. 141°38'56"E), with *Waagenoconcha humboldti* and *Scacchinella* sp.

### The Nagaiwa-Sakamotozawa fauna

The brachiopods of the Nagaiwa-Sakamotozawa area described in this report, and the number of specimens, are as follows:



**Fig. 3.** A distant view (A) and a close view (B) of the outcrop of sandstone of the lowest part of the Sakamotozawa Formation at the locality SK27 in the Nagaiwa-Sakamotozawa area.

<i>Waagenoconcha humboldti</i> (d'Orbigny, 1842).....	5
<i>Scacchinella</i> sp. ....	1
<i>Rhynchopora</i> sp. ....	1

Among these species, *Waagenoconcha humboldti* is known from the Upper Carboniferous (Gzhelian) to the Middle Permian (Capitanian) of northern Russia (Timan, Pechora Basin, northern Urals), western Russia (Moscow Basin), North China (Inner Mongolia), eastern Russia (South Primorye), northeast Japan (South Kitakami), and South America (Peru and Bolivia).

*Scacchinella* is known from the Upper Carboniferous (Gzhelian) to Upper Permian (Changhsingian) of Italy (Sicily), Austria (Carnic Alps), Slovenia (Karawanke Mountains), western Russia (southern Urals and northern Caucasus), Uzbekistan (Fergana), Japan (South Kitakami and Akasaka), Pakistan (Salt Range), and United States (West Texas), namely, Tethyan and Panthalassan regions (Tazawa and Araki, 1999; Shen et al., 2006).

According to Shi and Tazawa (2001), *Rhynchopora* is distributed in the Lower to Upper Permian of the middle and high latitudinal regions of both hemispheres, i.e., Mexico, western United States (Phosporia Basin), southwest Canada, Alaska, Arctic Canada (Yukon Territory and Sverdrup Basin), Spitsbergen, northern Russia (Kolyma, Verkhoyansk, Taimyr, northern Urals), western Russia (southern Urals), southeast Mongolia, Northwest China (Beishan), North China (Inner Mongolia), eastern Russia (South Primorye), northeast Japan (South Kitakami), central Japan (Hida Gaien), Southwest China (Yunnan), southwest Thailand, Tajikistan (Pamir), Malaysia, Nepal (Himalayas), Pakistan (Salt Range), western Australia, and Argentina.

Consequently, the Nagaiwa-Sakamotozawa fauna from the lowest part of the Sakamotozawa Formation is a mixed fauna of both Boreal- and Tethyan-type species. This finding suggest that the South Kitakami region was part of the continental shelf bordering the eastern margin of North China (Sino-Korea) during the Early Permian, as also reported for the Middle Permian (Tazawa, 1974, 1979, 1987a, 1991, 1998, 1999a, b, 2001, 2002, 2003, 2007, 2008d; Nakamura and Tazawa, 1990; Tazawa et al., 2000; Tazawa and Ibaraki, 2001) and the Late Permian (Tazawa, 1975, 1987b, 2008a, b; Nakamura and Tazawa, 1990).

### Systematic descriptions

Order Productida Sarytcheva and Sokolskaya, 1959

Suborder Productidina Waagen, 1883

Superfamily Echinoconchoidea Stehli, 1954

Family Echinoconchidae Stehli, 1954

Subfamily Juresaniinae Muir-Wood and Cooper, 1960

Tribe Waagenoconchini Muir-Wood and Cooper, 1960

Genus *Waagenoconcha* Chao, 1927

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

*Waagenoconcha humboldti* (d'Orbigny, 1842)

Figs. 4.1a-4.5b

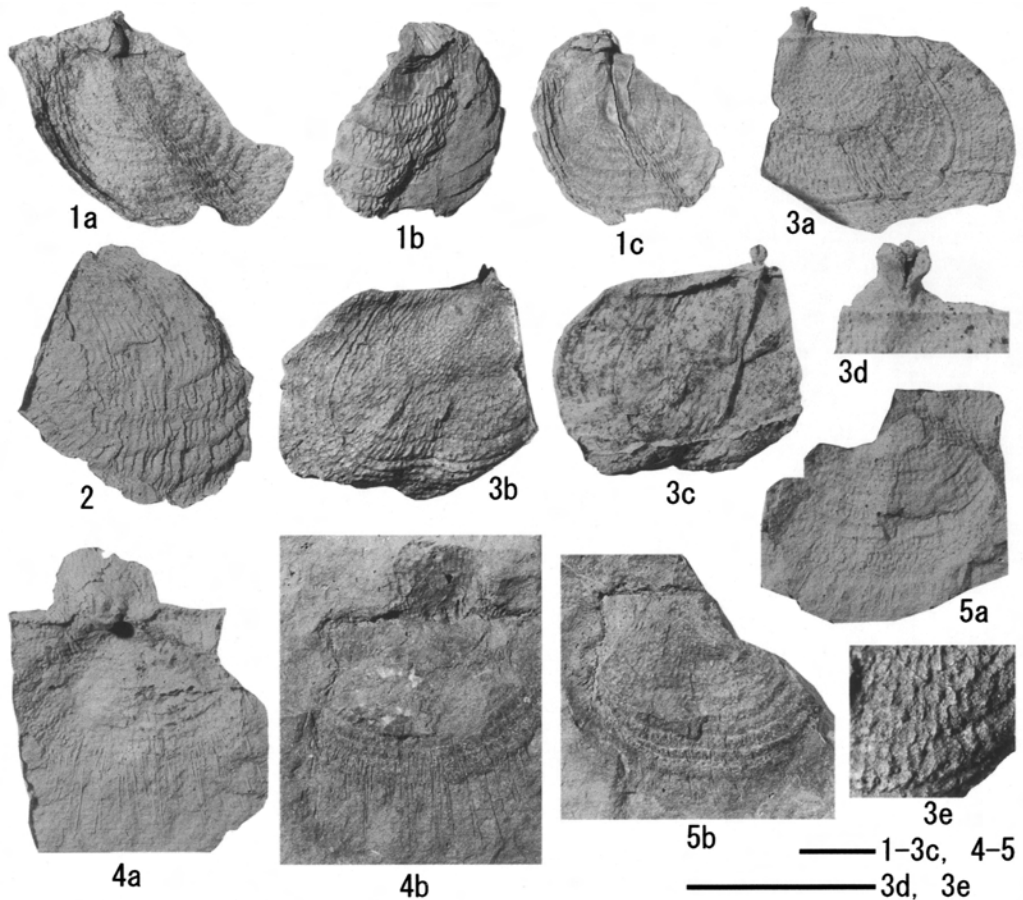
*Productus humboldti* d'Orbigny, 1842, p. 54, pl. 5, figs. 4-7; Tschernyschew, 1902, p. 275, 620, pl. 53, figs. 1a-3c; Kozłowski, 1914, p. 40, pl. 7, figs. 7a-9; Fredericks, 1925, p. 19, pl. 2, fig. 84.

*Waagenoconcha humboldti* (d'Orbigny): Chao, 1927, p. 86, pl. 15, figs. 2, 3; Sarytcheva and Sokolskaya, 1952, p. 98, pl. 15, fig. 109; Chronic, 1953, p. 86, pl. 15, figs. 4a-7; Muir-Wood and Cooper, 1960, p. 252, pl. 89, figs. 6-10; Samtleben, 1971, p. 60, pl. 2, figs. 17-19; Ifanova, 1972, p. 102, pl. 3, figs. 11a-13; Tazawa, 1974, p. 125, pl. 1, figs. 2, 3: pl. 2, fig. 1; pl. 4, fig. 6; Duan and Li, 1985, p. 108, pl. 35, figs. 2a-3b; Wang and Zhang, 2003, p. 94, pl. 9, figs. 5-7; pl. 15, figs. 8-10.

*Material.*—Five specimens from SK27: (1) internal moulds of a conjoined valve and external mould of the dorsal valve, NU-B1281; (2) external mould of a ventral valve, NU-B1282; (3) external and internal moulds of a dorsal valve, NU-B1283; (4) external mould of a dorsal valve, with umbonal region of the opposite ventral valve, NU-B1284, (5) external mould of a dorsal valve, NU-B1285.

*Description.*—Shell medium size for genus, transversely subrectangular in outline; hinge narrower than midwidth, the latter forming greatest width; length about 30 mm, width about 34 mm in the largest specimen (NU-B1284). Ventral valve moderately convex in both lateral and anterior profiles; umbo tapering, pointed and strongly incurved beyond hinge; ears small, triangular in shape, slightly constricted; sulcus broad and shallow. Dorsal valve with flat to slightly concave visceral disc, strongly geniculated at anterior margin, and followed by short trail; fold low and subcarinate, occurring just anterior to umbonal depression and extending to anterior margin. External surface of ventral valve ornamented with several strong concentric rugae and numerous, elongate, quincuncially arranged spine bases; numbering 4-5 spine bases in 5 mm width at midvalve. External ornament of dorsal valve similar to that of opposite valve, but rugae being more regularly and closely spaced, and spine bases being finer; numerous long spines visible on anterior valve margin. Dorsal valve interior with trilobed cardinal process followed by thick, long median septum, extending to nearly two-thirds of valve length; adductor scars elongate oval in shape and dendritic.

*Remarks.*—These specimens are referred to *Waagenoconcha humboldti* (d'Orbigny, 1842), originally described from the Lower Permian (Asselian) of Yarbichambi, Bolivia, on account of size, shape and external ornament of both valves, especially in their elongate spine bases and strong rugae on the ventral valve. Moreover, the large, thick trilobed cardinal process is similar to that of the Bolivian specimen illustrated by Kozłowski (1914, text-fig. 9).



**Fig. 4. 1a-5b:** *Waagenoconcha humboldti* (d'Orbigny, 1842), from the locality SK27, 1a, 1b, 1c: external latex cast of dorsal valve, and ventral and dorsal views of internal mould of conjoined valve, NU-B1281, 2: external latex cast of ventral valve, NU-B1282, 3a, 3b, 3c, 3d, 3e: external latex cast, external mould, internal latex cast of dorsal valve, dorsal view of latex cast of trifid cardinal process, and external surface ornament of dorsal valve, NU-B1283, 4a, 4b: external latex cast and external mould of dorsal valve with umbonal region of ventral valve, NU-B1284, 5a, 5b: external latex cast and external mould of dorsal valve, NU-B1285. Scale bars represent 1 cm.

*Waagenoconcha irginae* (Stuckenberg, 1898, p. 220, pl. 2, fig. 16) from the Lower Permian (Asselian) of the Urals is similar in general shape, but it differs from *W. humboldti* in its larger size and finer spine bases on the both ventral and dorsal valves.

*Distribution.*—Upper carboniferous (Gzhelian) of western Russia (Moscow Basin); Lower Permian (Asselian) of northern Russia (northern Urals and Timan) and South America (Peru and Bolivia); Lower Permian (Sakmarian) of northeast Japan (South Kitakami); Lower Permian (Artinskian-Kungurian) of northern Russia (Pechora Basin); Middle Permian

(Wordian) of eastern Russia (South Primorye) and northeast Japan (South Kitakami); Middle Permian (Wordian-Capitanian) of North China (Inner Mongolia).

Superfamily Aulostegoidea Muir-Wood and Cooper, 1960

Family Scacchinellidae Licharew, 1928

Subfamily Scacchinellinae Licharew, 1928

Genus *Scacchinella* Gemmellaro, 1891

*Type species.*—*Scacchinella variabilis* Gemmellaro, 1897.

*Scacchinella* sp.

Figs. 5.2a-5.2f

*Material.*—One specimen from locality SK27, external and internal moulds of a ventral valve, NU-B1286.

*Remarks.*—The single incomplete specimen from the Nagaiwa-Sakamotozawa area can be referred to the genus *Scacchinella* by its large (length about 28 mm, width about 38 mm), conical-shaped ventral valve, with a high, flat, both horizontally and longitudinally striated interarea, and external ornament consisting of strong irregular rugae and numerous fine spine bases over the anterolateral slopes.

In size and shape of the ventral valve, this specimen resembles *Scacchinella gigantea* Shellwien, 1900, originally described by Shellwien (1900, p. 35, pl. 4, figs. 1-3; pl. 5, figs. 1-8; text-figs. 5, 6, 8) from the Trogkofel Limestone (Sakmarian) of the Carnic Alps, and subsequently described by Tazawa and Araki (1999, p. 453, figs. 2.1-2.4) from the upper Kanokura Formation (Capitanian) of Omotematsukawa in the Kesenuma area, South Kitakami Belt. The present material is, however, too imperfect for comparison.

Order Rhynchonellida Kuhn, 1949

Superfamily Rhynchoporoidea Muir-Wood, 1955

Family Rhynchoporidae Muir-Wood, 1955

Subfamily Rhynchoporinae Muir-Wood, 1955

Genus *Rhynchopora* King, 1865

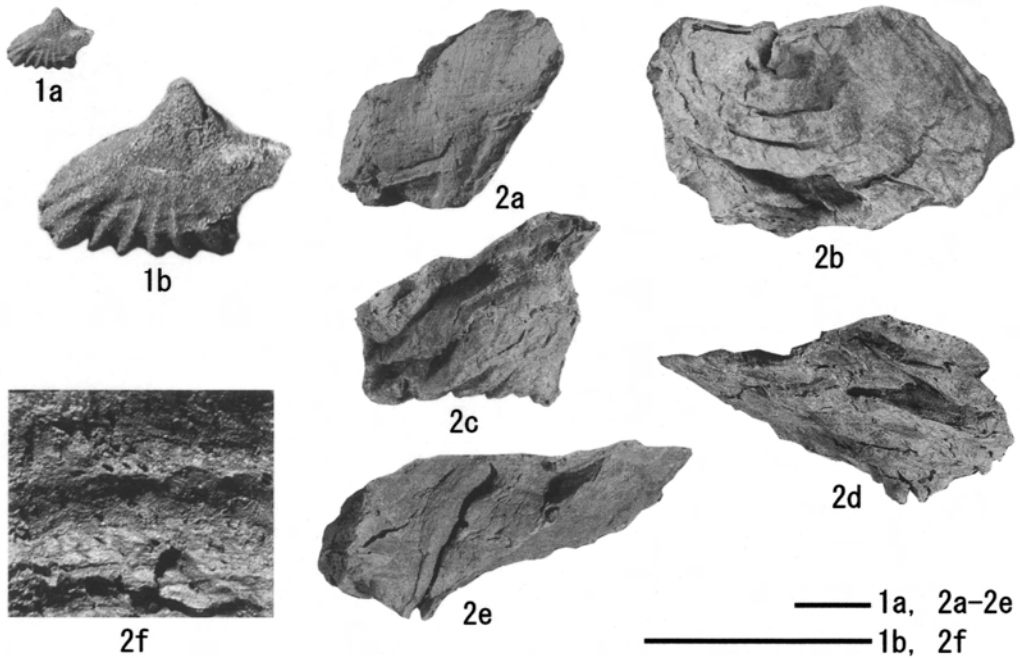
*Type species.*—*Terebratula geinitziana* de Verneuil, 1845.

*Rhynchopora* sp.

Figs. 5.1a, 5.1b

*Material.*—One specimen from SK05, internal mould of a ventral valve, NU-B1280.





**Fig. 5.** **1a, 1b:** *Rhynchopora* sp., from the locality SK05, internal mould of ventral valve, NU-B1280, **2a-2f:** *Scacchinella* sp., from the locality SK27, 2a: posterior view of external latex cast of ventral valve, showing flat interarea, 2b, 2c, 2d, 2e: ventral, lateral, anterior and posterior views of internal mould of ventral valve, 2f: external surface ornament of ventral lateral slope, NU-B1286. Scale bars represent 1 cm.

*Remarks.*—This specimen is safely assigned to the genus *Rhynchopora* by its small, transversely subpentagonal ventral valve (length about 8 mm, width about 12 mm), deep and broad sulcus, simple costae numbering 5 on the sulcus and 4 on each of the lateral slopes, and thin, short dental plates. The Sakamotozawa specimen somewhat resembles shells described as *Rhynchopora tschernyshae* Koczyrkevich, 1979 from the upper Oyakejima Formation of Ogatsu in the South Kitakami Belt, northeast Japan (Tazawa et al., 2000, p. 10, pl. 1, figs. 6a-6d), and *Rhynchopora* sp. from the Mizukoshi Formation of Mizukoshi, central Kyushu, southwest Japan (Tazawa, 2008c, p. 54, figs. 8.11a, 8.11b) in size, outline and surface ornament of the ventral valve. However, the single imperfect specimen does not allow specific assignment.

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