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Leptodus and *Spiriferella* (Permian Brachiopoda) from the Usuginu Conglomerate, southern Kitakami Mountains, northeast Japan

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Abstract

Two Permian brachiopod species, *Leptodus* sp. and *Spiriferella keilhavii* are described from a sandstone block of the Usuginu Conglomerate in the Ichinoseki district, southern Kitakami Mountains, northeast Japan. The occurrence of a Tethyan-type brachiopod *Leptodus* together with a Boreal-type brachiopod *Spiriferella* suggests that the source area of the the Usuginu Conglomerate was probably a continental shelf bordering the eastern margin of the Sino-Korean Continent in Middle Permian time.

Key words: Brachiopods, *Leptodus*, Permian, southern Kitakami Mountains, *Spiriferella*, Usuginu Conglomerate.

Introduction

The brachiopods described below were collected from a sandstone block of the upper part of the Usuginu Conglomerate in Fujinosawa, about 6 km east of Ichinoseki, southern Kitakami Mountains, northeast Japan (Fig. 1). Geology of the Ichinoseki district, especially stratigraphy and sedimentary facies of the Usuginu Conglomerate, was described in detail by Yoshida and Machiyama (1998). According to them, the Usuginu Conglomerate is about 1,500 m in total thickness, and the upper part is characterized by bearing many large blocks of sandstone, mudstone and limestone. The sandstone block containing brachiopod fossils is 120 cm×60 cm in size, and consists of dark grey, fine-grained calcareous sandstone. The brachiopod specimens are relatively well preserved, and identified to *Leptodus* sp. and *Spiriferella keilhavii* (von Buch, 1846). The latter one indicates Middle Permian (Bolorian-Midian) age (Waterhouse and Waddington, 1982).

The purpose of this paper is to describe the Middle Permian brachiopods from the sandstone block of the Usuginu Conglomerate in the Ichinoseki district, and to discuss the palaeogeography of the source area of this conglomerate. The fossils are registered in the collection of the Department of Geology, Faculty of Science, Niigata University as specimens NU-B185-NU-B190.

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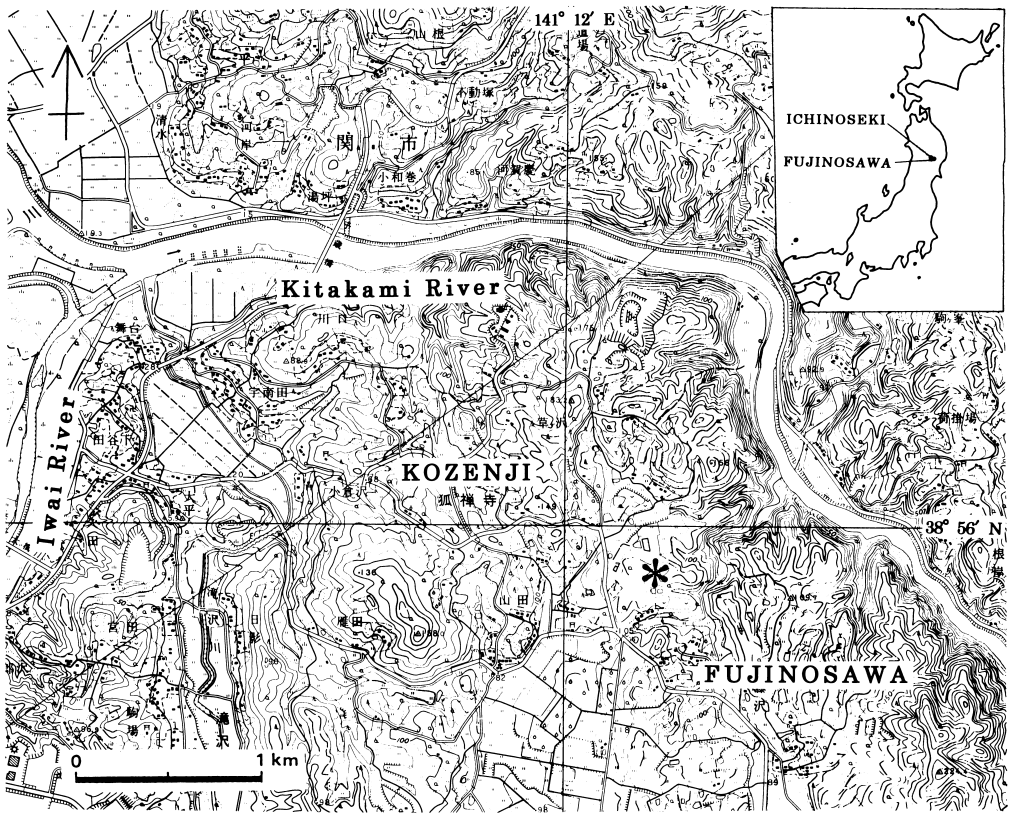

Fig. 1. Map showing the fossil locality (asterisk). Using the topographical map of "Ichinoseki" scale 1:25,000 published by Geographical Survey Institution of Japan.

Age of the Usuginu Conglomerate

The age of the Usuginu Conglomerate is considered biostratigraphically and sedimentologically to be early Late Permian (Dzhulfian), although the previous authors (Ehiro, 1989; Yoshida and Machiyama, 1998) regarded as late Middle Permian. In the Ichinoseki district, the Usuginu Conglomerate overlies the Lower Permian Nozuchi Formation, and is in turn overlain conformably by the Upper Permian Toyoma Formation (Osawa *et al* ., 1981; Yoshida and Machiyama, 1998). The Middle Permian sequence was eroded away completely, and not preserved in this district. Some fusulinaceans and rugose corals, such as *Lepidolina, Rauserella, Wentzelella* and *Wentzelloides*, which occur commonly from the upper Kanokura Formation (Iwaizaki Stage of Minato *et al.*, 1978; correlated with the Midian) of the southern Kitakami Mountains, were found from limestone blocks and mudstone matrix of the Usuginu Conglomerate (Machiyama and

Yoshida, 1995; Yoshida and Machiyama, 1998). However, the sole specimen of *Lepidolina multiseptata* (Deprat), collected and figured by Yoshida and Machiyama (1998, fig. 5A) from the mudstone matrix is fragmental, and it appears to be a derived fossil. Consequently these above-cited fossils are inadequate to use for indicator of the Usuginu Conglomerate age. The age of this conglomerate must be later than late Middle Permian, and it is probable early Late Permian (Dzhulfian).

Source area of the Usuginu Conglomerate

Leptodus is a typical Tethyan-type brachiopod genus, and is distributed in the Lower Permian (Sakmarian) to Upper Permian (Dorashamian) of the Tethyan, and its neighbouring regions: Hungary (Schréter, 1963), Croatia (Sremac, 1986), Serbia (Simic, 1933), Transcaucasia (Licharew, 1932; Sarytcheva, 1964; Ruzhentsev and Sarytcheva, 1965; Kotljar in Kotljar and Zakharov., 1989), Pamir (Tschernyschew, 1914; Grunt and Dmitriev, 1973), Salt Range (Waagen, 1883; Noetling, 1904, 1905; Frech, 1911; Fredericks, 1916; Reed, 1944; Cooper and Grant, 1974), Khisor Range (Grant, 1970) and Surghar Range (Grant, 1970) in Pakistan, Kashmir (Diener, 1899, 1915), Kumaon Himalayas (Diener, 1897), Tibet (Jing and Sun, 1981; Zhan and Wu, 1982), southern Thailand (Grant, 1976; Waterhouse and Piyasin, 1970; Yanagida, 1970), Cambodia (Mansuy, 1913, 1914; Termier and Termier, 1960; Chi-Thuan, 1961), Laos (Mansuy, 1912), Vietnam (Colani, 1919; Chi-Thuan, 1962), Timor (Hamlet, 1928; Wanner and Sieverts, 1935), Port Keats in northern Australia (Thomas, 1957), Yunnan (Huang, 1936; Fang and Fan, 1994), Sichuan (Hayasaka, 1917, 1922b; Huang, 1932; Tong, 1978; Xu, 1987; Shen *et al* ., 1992), Guizhou (Hayasaka, 1917, 1922b; Huang, 1932; Feng and Jiang, 1978; Liao, 1980), Guangxi (Hayasaka, 1922b; Huang, 1933, 1936; Yang *et al.*, 1977), Guangdong (Yang *et al.*, 1977; Zhan, 1979), Hunan (Yang *et al.*, 1977; Liu *et al.*, 1982; Liao and Meng, 1986) and Hubei (Yang *et al.*, 1977; Yang, 1984) in South China, Jiangxi (Kayser, 1883; Frech, 1911; Hayasaka, 1922b; Huang, 1932; Wang *et al.*, 1982), Fujian (Wang *et al.*, 1982; Xu, 1987; Zhu, 1990), Zhejiang (Wang *et al.*, 1982; Liang, 1990) and Anhui (Jing and Hu, 1978; Wang *et al.*, 1982) in East China, Shaanxi (Zhang, 1996), Gansu (Zhang *et al.*, 1983) and Qinghai (Jin *et al.*, 1979) in Northwest China, Inner Mongolia (Grabau, 1931; Lee and Gu, 1976; Lee *et al.*, 1980; Duan and Li, 1985), Heilongjiang (Lee *et al.*, 1980) and Jilin (Lee *et al.*, 1980) in Northeast China, South Primorye in eastern Russia (Licharew and Kotljar, 1978; Kotljar in Kotljar and Zakharov, 1989), and South Kitakami Belt (Yabe, 1900; Hayasaka, 1917, 1922a, 1960; Tazawa, 1976, 1987; Minato *et al.*, 1979), Hida Gaien Belt (Tazawa, 1987; Tazawa and Matsumoto, 1998), Maizuru Belt (Mashiko, 1934; Shimizu, 1961) and Akiyoshi Belt (Yanagida, 1996) in Japan.

On the other hand, *Spiriferella keilhavii* is a Boreal-type brachiopod species, and is distributed in the Middle Permian (Bolorian-Midian) of the Boreal region and transitional (boundary) zone between the Boreal and Tetyan regions: Yukon Territory (Nelson and Johnson, 1968; Bamber and Waterhouse, 1971), Devon Island (Harker, 1960) and Ellesmere Island (Waterhouse and Waddington, 1982) in Arctic Canada, Greenland (Frebold, 1931; Dunbar, 1955), Spitsbergen (Wiman, 1914; Frebold, 1937; Stepanov, 1937; Gobbett, 1963) and Bear Island (von Buch, 1846;

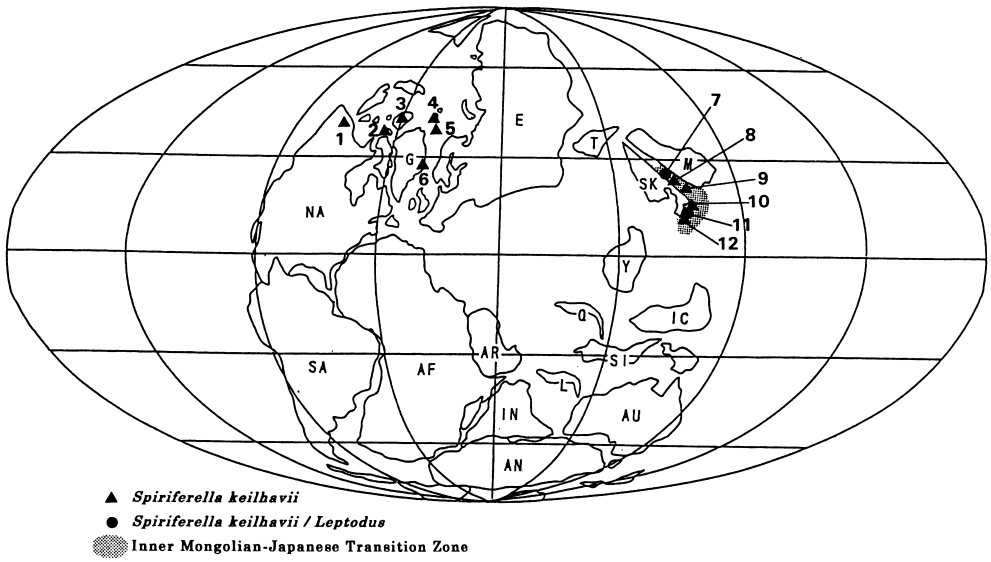

Fig. 2. Geographical distribution of *Spiriferella keilhavii* with/ without *Leptodus* in Middle Permian (adapted from Ziegler *et al.*, 1996). 1: northern Yukon Territory, 2: Devon Island, 3: Ellesmere Island, 4: Spitsbergen, 5: Bear Island, 6: east Greenland, 7: Jisu, Inner Mongolia, 8: Xiujimqin and Ongniud, Inner Mongolia, 9: Acheng, Heilongjiang, 10: Mizukoshi, central Kyushu, 11: southern Kitakami Mountains, 12: Abukuma Mountains, AF: Africa, AN: Antarctica, AR: Arabia, AU: Australia, E: Eurasia, G: Greenland, IC: Indochina, IN: India, L: Lhasa, M: Mongolia, NA: North America, Q: Qangtang, SA: South America, SI: Sibumasu, SK: Sino-Korea, T: Tarim, Y: Yangtze.

Wiman, 1914) in Svalbard, Jisu (Grabau, 1931), Xi Ujimqin (Lee *et al.*, 1985) and Ongniud (Lee *et al.*, 1980) in Inner Mongolia, Heilongjiang (Lee *et al.*, 1980) in Northeast China, and South Kitakami Belt (Koizumi, 1979; Minato *et al.*, 1979; Tazawa and Gunji, 1982) and Mizukoshi of Hida Gaien Belt (Yanagida, 1963) in Japan (Fig. 2).

The areas having both *S. keilhavii* and *Leptodus* species are restricted geographically to a transitional zone (or boundary zone) between the Tethyan and Boreal Realms in east Asia, i.e., the Inner Mongolian-Japanese Transition Zone of Tazawa (1991), which includes Inner Mongolia, Northeast China, South Primorye and the South Kitakami and Hida Gaien Belts in Japan (Fig. 2). The Ichinoseki district belongs to this transitional zone. The source area of the Usuginu Conglomerate was probably a part of a continental shelf along the eastern margin of the Sino-Korean Continent in Middle Permian time, similar to the other districts in the Inner Mongolian-Japanese Transition Zone (Tazawa, 1991, 1992, 1996, 1997).

Description of Species

Order Productida Waagen, 1883

Suborder Strophalosiidina Waagen, 1883
Superfamily Lyttonioidea Waagen, 1883
Family Lyttoniidae Waagen, 1883
Subfamily Lyttoniinae Waagen, 1883
Genus *Leptodus* Kayser, 1883

Leptodus sp.
Pl. 1, figs. 1a, 1b.

Material.–One specimen, internal mould of a pedicle valve, NU-B190.

Remarks.–This specimen is safely assigned to the genus *Leptodus* by having 3 to 5 regularly and symmetrically arranged, broad and solid lateral septa on each side of the median septum. The Ichinoseki specimen is small in size (length 18 mm, width 17 mm), and it may be a young shell of *Leptodus nobilis* (Waagen, 1883), which occurs commonly in the Middle Permian Kanokura Formation of the southern Kitakami Mountains (Hayasaka, 1917, 1922a, 1960; Tazawa, 1976, 1987; Minato *et al.*, 1979). But specific identification is difficult on such a young specimen.

Order Spiriferida Waagen, 1883
Suborder Spiriferidina Waagen, 1883
Superfamily Spiriferoidea King, 1846
Family Spiriferellidae Waterhouse, 1968
Subfamily Spiriferellinae Waterhouse, 1968
Genus *Spiriferella* Tschernyschew, 1902

Spiriferella keilhavii (von Buch, 1846)
Pl. 1, figs. 2-6.

Spirifer keilhavii von Buch, p. 74, figs. 2a, b.
Spiriferina keilhavii (von Buch): Wiman, 1914, pl. 2, figs. 25-30; pl. 3, fig. 1.
Spiriferina draschei (Toula): Wiman, 1914, p. 38, pl. 3, fig. 2 only.
Spiriferella keilhavii (von Buch): Frebold, 1931, p. 28, pl. 5, figs. 7-9; Grabau, 1931, p. 164, pl. 20, figs. 9a-c; pl. 21, figs. 1-5; Frebold, 1937, p. 46, pl. 11, fig. 9; Stepanov, 1937, p. 143, 179, pl. 7, figs. 8-11; Dunbar, 1955, p. 139, pl. 25, figs. 1-9; pl. 26, figs. 1-11; pl. 27, figs. 1-14; Harker, 1960, p. 72, pl. 22, figs. 9-11; pl. 23, figs. 1, 2; Gobbett, 1963, p. 152, pl. 20, figs. 8-10; Yanagida, 1963, pl. 9, figs. 4-9; pl. 10, figs. 1-7; Nelson and Johnson, 1968, p. 736, pl. 96, figs. 7, 8, 12; text-figs. 3e, 8a, 9, 13b; Koizumi, 1979, pl. 1, figs. 10, 11 only; Minato *et al.*, 1979, pl. 67, figs. 1-3; Lee *et al.*, 1980, p. 418, pl. 178, fig. 8; Tazawa and Gunji, 1982, p. 70, pl. 4, figs. 4-7; Waterhouse and Waddington, 1982, p. 28, pl. 6, figs. 3-14; text-figs.16e, g, h, i, 19; not pl. 4, fig. 15; Lee *et al.*, 1985, p. 122, pl. 2, figs. 1a, b, 5, 8.
Spiriferella parryana (Toula): Frebold, 1937, p. 45, pl. 11, fig. 6.
Spiriferella aff. *keilhavii* (von Buch): Bamber and Waterhouse, 1971, pl. 20, fig. 7.

Material.–Five specimens: (1) external mould of a pedicle valve and internal mould of a conjoined valve, NU-B185; (2) external mould of a pedicle valve, NU-B186; (3) internal mould of a conjoined valve, NU-B187; (4) internal mould of a pedicle valve with the external mould of the posterior portion attached, NU-B188; (5) internal mould of a brachial valve, NU-B189.

Description.–Shell large size for genus, biconvex, slightly wider subquadrate in outline, with greatest width near hinge line; length about 44 mm, width about 55 mm in the best preserved pedicle valve specimen (NU-B185); length more than 45 mm, width about 60 mm in the largest pedicle valve specimen (NU-B186).

Pedicle valve gently convex in lateral profile, with maximum convexity at umbonal slope. Beak not preserved. Interarea low, broad and gently concave, with large delthyrium: delthydial angle 55° in one specimen (NU-B188). Sulcus wide and deep, with flat bottom and two minor costae on each side of inner slopes. External surface of pedicle valve ornamented by several fairly strong costae and numerous very fine concentric lirae. Costae broad, rounded, bifurcating asymmetrically about 10-15 mm anterior to beaks, and producing fascicles of 2-3; costae numbering 5-6 on each lateral side to sulcus.

Internally, pedicle valve having a deeply impressed, large, heart-shaped muscle field and a pair of long dental plates. Adductors long and narrow. Diductors wide and weakly striated longitudinally. Internal structures of brachial valve not well-preserved and obscure.

Remarks.–These specimens are referred to *Spiriferella keilhavii* (von Buch, 1846), originally described from the Middle Permian of Mt. Misery, Bear Island, by their transverse shell and weakly fasciculated costae on the pedicle valve.

Spiriferella lita Fredericks, 1924, from the Chandalaz Formation of South Primorye (Fredericks, 1924, p. 36, pl. 1, figs. 16-27; text-fig. 2) is also a large, transverse *Spiriferella*, but the Russian species is distinguished from *S. keilhavii* by its simple costae on the pedicle valve.

Spiriferella loveni (Diener, 1903), redescribed and refigured by Waterhouse and Waddington (1982, p. 22, pl. 5, figs. 2-17; pl. 6, figs. 1, 2; text-figs. 16b, d, f, 17, 18) on the specimens from the Middle Permian of the Canadian Arctic region, is like to *S. keilhavii* in size, shape and surface ornament of the pedicle valve. *S. loveni* is distinguished from *S. keilhavii* by its high, distinct dorsal fold with a broad, deep median groove. Three brachial valve specimens from Ichinoseki, which are represented by the internal moulds, have broad but low dorsal fold with a narrow median groove or none at all.

Distribution.–Tahkandit Formation of northern Yukon Territory; Assistance Formation of Grinnell Peninsula, Devon Island, Arctic Canada; Upper Sandstone Unit (GC Zone) of Ellesmere Island, Arctic Canada; Foldvik Creek Formation, east Greenland; Kapp Starostin Formation of Spitsbergen and its equivalent of Bear Island, Svalbard; Jisu (Zhesi) Formation of Jisu and Xiujimqin, Inner Mongolia; Huangganglіang Formation of Ongniud, Inner Mongolia; Tumenling Formation of Acheng, Heilongjiang Province, Northeast China: Mizukoshi Formation of Mizukoshi, central Kyushu, southwest Japan; Kashiwadaira Formation of Takakurayama, Abukuma Mountains, northeast Japan; Oashi Formation of Soma, Abukuma Mountains, northeast Japan; Lower Kanokura Formation of Setamai and Imo, southern Kitakami Mountains, northeast Japan.

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Explanation of Plate 1

(Natural size unless otherwise indicated)

Figs. 1a, b. *Leptodus* sp.

Internal mould of pedicle valve, NU-B190, (1b×2).

Figs. 2-6. *Spiriferella keilhavii* (von Buch)

2. Latex cast of pedicle valve, NU-B186, 3a, b. Internal mould of conjoined valve, ventral and dorsal views, NU-B187, 4a, b. External mould and latex cast of pedicle valve, NU-B188, 5a, b, c. Internal mould and latex cast of pedicle valve, and internal mould of bracial valve, NU-B185.

Plate 1