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Source: Paleontological Research, 23(3) : 192-198

Published By: The Palaeontological Society of Japan

URL: <https://doi.org/10.2517/2018PR019>

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Two early Carboniferous brachiopods, *Levitusia humerosa* (Sowerby, 1822) and *Grandispirifer mylkensis* Yang, 1959, from the Arisu Formation of Okuhinotsuchi, South Kitakami Belt, Japan

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Received February 21, 2018; Revised manuscript accepted September 3, 2018

Abstract. Two early Carboniferous brachiopod species, *Levitusia humerosa* (Sowerby) and *Grandispirifer mylkensis* Yang, are described from Japan for the first time. These species, from the middle part of the Arisu Formation in the Okuhinotsuchi area, South Kitakami Belt, indicate an early Visean age. Therefore, the middle part of the Arisu Formation is correlated with the lower Visean. In terms of palaeobiogeography, occurrence of the two species suggests that South Kitakami was probably the eastern extension of the North China Province, and located near and to the east of North China (Sino-Korea) during the early Visean.

Key words: Brachiopoda, *Grandispirifer mylkensis*, *Levitusia humerosa*, South Kitakami Belt, Visean

Introduction

This paper describes two early Carboniferous brachiopod species, *Levitusia humerosa* (Sowerby, 1822) and *Grandispirifer mylkensis* Yang, 1959, for the first time from Japan. The brachiopod fossils were collected from the middle part of the Arisu Formation in the Okuhinotsuchi area, South Kitakami Belt, northeastern Japan (Figure 1). In the South Kitakami Belt, the Arisu Formation occurs in the central part of the belt, i.e., in the Yokota, Shimoarisu and Okuhinotsuchi areas. The stratigraphy of the Arisu Formation has been studied previously (Minato, 1941; Minato *et al.*, 1953, 1979; Onuki, 1956, 1969, 1981; Takeda, 1960; Saito, 1966, 1968; Tazawa and Katayama, 1979; Kawamura, 1985a, 1985b; Tazawa and Iryu, 2019). However, the age of the formation is still controversial, having been identified as late Tournaisian to early Visean (Minato *et al.*, 1953), late Tournaisian (Minato and Kato, 1979), and early Visean (Tazawa, 1985; Kawamura and Kawamura, 1989; Tazawa and Iryu, 2019), owing to a paucity of fossil evidence. The occurrence of *Levitusia humerosa* and *Grandispirifer mylkensis* in the middle part of the Arisu Formation provides reliable evidence for the age of the formation. In terms of palaeobiogeography, the senior author (J. Tazawa) stated that South Kitakami was

probably the eastern extension of the North China Province (of Yang, 1980, 1983) or the Tianshan–Jilin Province (of Yang, 1994) on the basis of brachiopods from the lower Carboniferous of the South Kitakami Belt (Tazawa, 2002, 2006, 2017, 2018; Tazawa and Iryu, 2019). The occurrence of the above two species from Okuhinotsuchi provides additional evidence for this hypothesis.

Stratigraphy and material

The Carboniferous rocks of the Okuhinotsuchi area are divided on the basis of lithology into the Shittakazawa, Arisu, Odaira, Onimaru and Nagaiwa formations, in ascending stratigraphic order. The Odaira Formation corresponds to the Karoyama Formation of Tazawa *et al.* (1981). According to unpublished data of the present authors, the Arisu Formation of the Okuhinotsuchi area can be subdivided into a lower part (dark green andesitic lapilli tuff, 157 m thick), a middle part (alternating shale and sandstone, intercalated with andesitic tuff, 343 m thick) and an upper part (black shale, 57 m thick), with a total thickness of 557 m (Figure 2). The brachiopod specimens described herein were collected by one of the authors (H. Kurita) from greenish-grey tuffaceous sandstone in the middle part of the Arisu Forma-

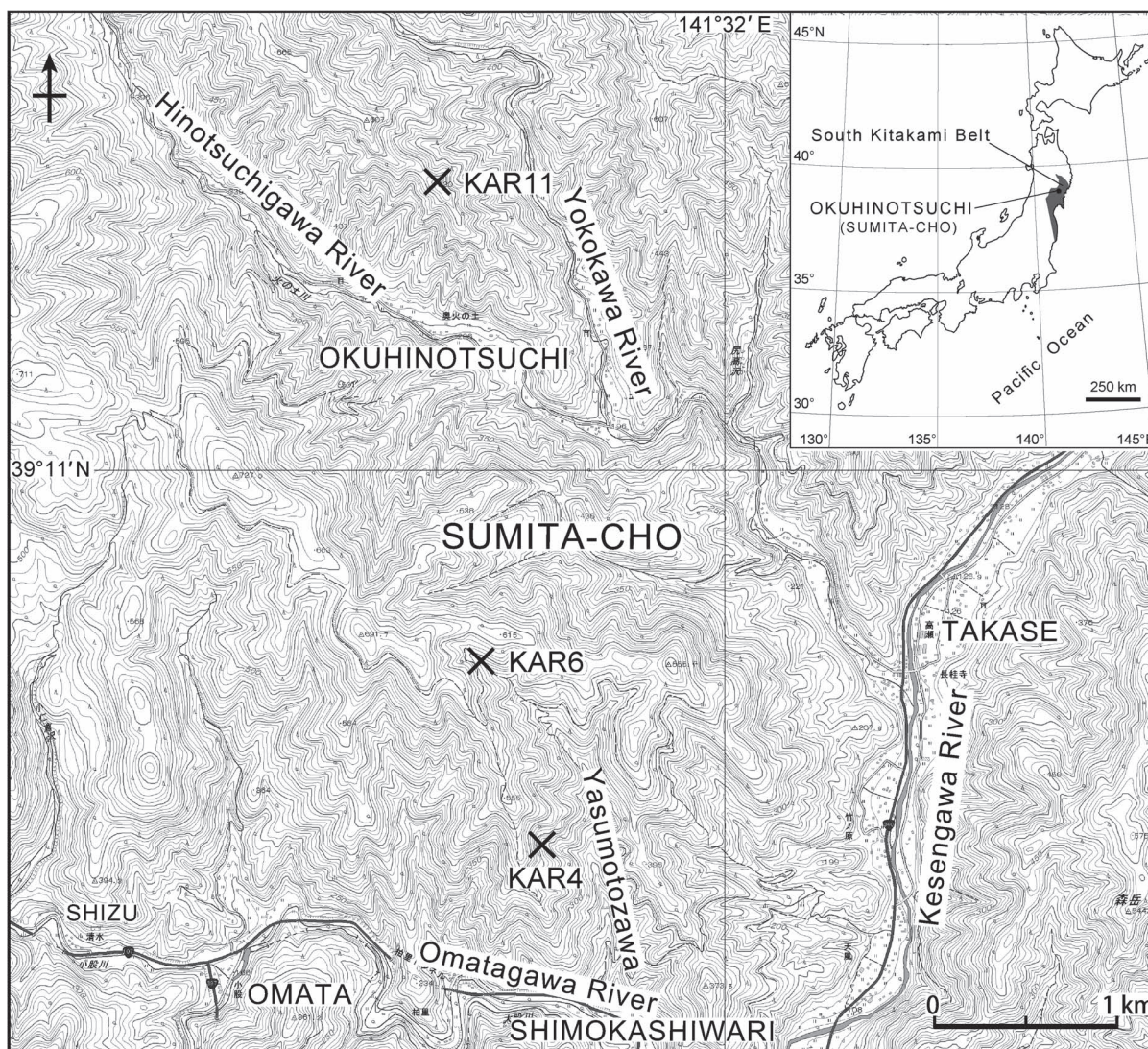


Figure 1. Map showing the fossil localities KAR4, KAR6 and KAR11 in the Okuhinotsuchi area, South Kitakami Belt (using a digital topographic map of the Geospatial Information Authority of Japan).

tion at three localities (KAR4, KAR6 and KAR11) in the Okuhinotsuchi area. The location, horizon, lithology and brachiopod species of each site are as follows:

KAR4: Upper Yasumotozawa Valley (39°09'54"N, 141°31'18"E), 1.1 km northwest of Shimokashiwari, outcrop of greenish-grey medium-grained tuffaceous sandstone 114 m above the base of the middle part of the Arisu Formation, with *Grandispirifer mylkensis*.

KAR6: Upper Yasumotozawa Valley (39°10'26"N, 141°31'05"E), 2.9 km northwest of Shimokashiwari, outcrop of greenish-grey coarse-grained tuffaceous sandstone 36 m above the base of the middle part of the Arisu Formation, with *Gran-*

dispirifer mylkensis.

KAR11: Ridge (39°11'52"N, 141°30'53"E), 0.8 km north of Okuhinotsuchi, outcrop of greenish-grey, coarse-grained tuffaceous sandstone 150 m above the base of the middle part of the Arisu Formation, with *Levitusia humerosa*.

Stratigraphic and palaeobiogeographic significance of *Levitusia humerosa* and *Grandispirifer mylkensis*

Levitusia humerosa is known from the lower Visean of northeastern Japan (this study), England (Sowerby, 1822; Davidson, 1861; Muir-Wood and Cooper, 1960;

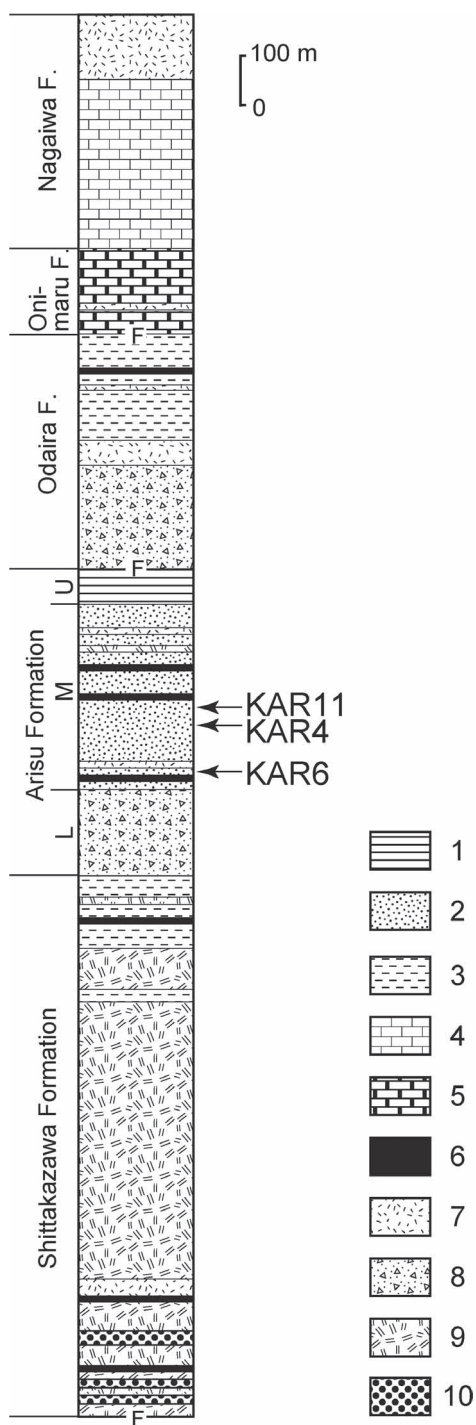


Figure 2. Generalized columnar section of the Carboniferous succession in the Okuhinotsuchi area, South Kitakami Belt, showing the fossil horizons of localities KAR4, KAR6 and KAR11. Legend: 1, shale; 2, sandstone; 3, alternating sandstone and shale; 4, limestone of the Nagaiwa Formation; 5, limestone of the Onimaru Formation; 6, limestone of the Odaira, Arisu and Shittakazawa formations; 7, andesitic-basaltic tuff; 8, andesitic-basaltic lapilli tuff; 9, rhyolitic tuff; 10, conglomerate. “F” denotes a fault contact.

Brunton, 1979), Belgium (Muir-Wood and Cooper, 1960; Brunton, 1979), Germany (Paeckelmann, 1931), western Russia (Rotai, 1931; Garanj *et al.*, 1975), central Russia (Rotai, 1941; Nalivkin and Fotieva, 1973; Nalivkin, 1979), Uzbekistan (Yanishevsky, 1918) and Kyrgyzstan (Galitskaya, 1977). *Grandispirifer mylkensis* has been reported from the upper Tournaisian to lower Visean of northeastern Japan (this study) and northwestern China (Yang, 1959, 1964; Yang *et al.*, 1962; Zhang *et al.*, 1983; Shi *et al.*, 2016).

Thus, the age of the middle part of the Arisu Formation is identified as early Visean on the basis of the co-occurrence of *Levitusia humerosa* and *Grandispirifer mylkensis*; and the middle part of the Arisu Formation at Okuhinotsuchi is correlated with the lower Visean. This conclusion is consistent with the correlation and age determination by Tazawa and Iryu (2019), which is based on the brachiopod fauna from the middle part of the Arisu Formation at Shimoarisu, east of Okuhinotsuchi, in the South Kitakami Belt. In terms of palaeobiogeography, both species are known from central Asia (Uzbekistan, Kyrgyzstan and northwestern China), but are absent from South China (Yangtze). These data suggest that the South Kitakami region, including Okuhinotsuchi, was the eastern extension of the North China Province (of Yang, 1980, 1983) and located near and to the east of North China (Sino-Korea) in early Visean.

Systematic descriptions

(by J. Tazawa)

The specimens described below are registered and housed in the Tohoku University Museum, Sendai, Japan (prefix IGPS, numbers IGPS111742 to IGPS111744).

Order Productida Sarytcheva and Sokolskaya, 1959
Suborder Productidina Waagen, 1883
Superfamily Horridonioidea Muir-Wood and Cooper, 1960

Family Leioproductidae Muir-Wood and Cooper, 1960
Subfamily Levitusiinae Muir-Wood and Cooper, 1960
Genus *Levitusia* Muir-Wood and Cooper, 1960

Type species.—*Productus humerosus* Sowerby, 1822.

Levitusia humerosa (Sowerby, 1822)

Figure 3

Productus humerosus Sowerby, 1822, p. 21, fig. 322; Davidson, 1861, p. 147, pl. 36, figs. 1, 2; Yanishevsky, 1918, p. 38, pl. 3, figs. 1–5.
Productus sublaevis de Koninck. Davidson, 1861, p. 177, pl. 31, figs. 1, 2; pl. 32, fig. 1; pl. 51, figs. 1, 2; Rotai, 1931, p. 50, pl. 1, figs. 7, 8; pl. 2, figs. 1, 5.

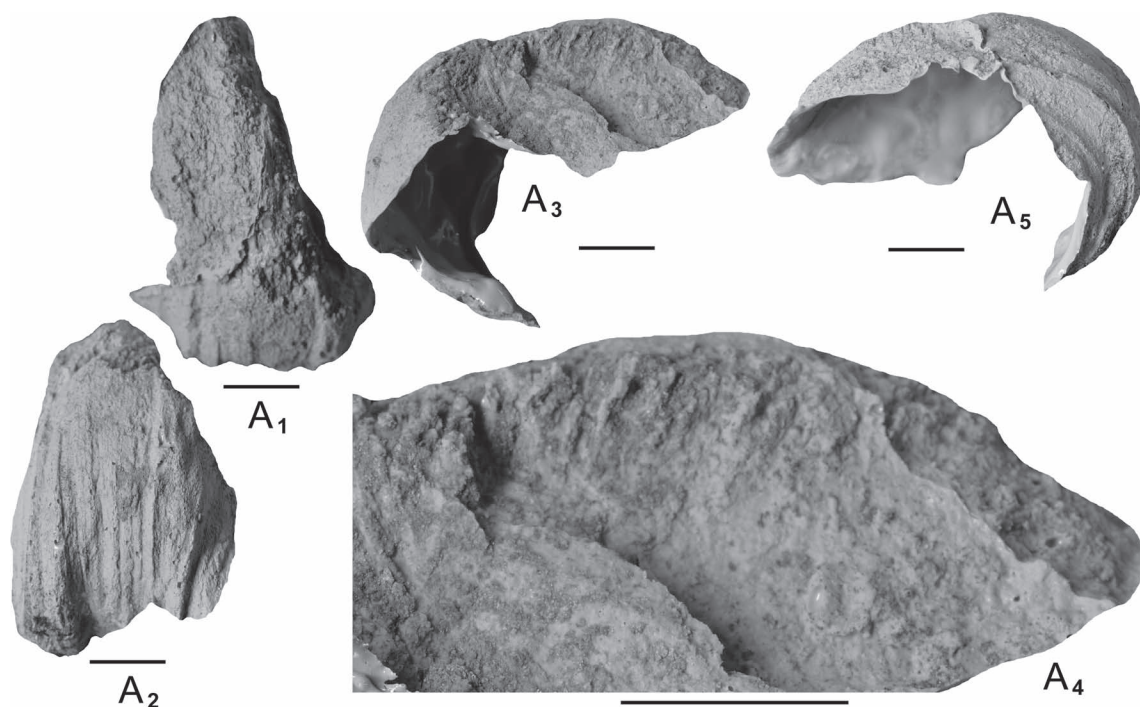


Figure 3. *Levitusia humerosa* (Sowerby) from the Arisu Formation of Okuhinotsuchi; ventral (A₁), anterior (A₂) and lateral (A₃, A₄, A₅) views of external latex cast of ventral valve, IGPS111744. Scale bars are 1 cm.

Productus (Plicatifera) humerosus Sowerby. Paeckelmann, 1931, p. 120, pl. 6, fig. 5; pl. 7, figs. 1–4; pl. 8, figs. 1–3; pl. 11, fig. 1; Rotai, 1941, p. 96, pl. 17, figs. 3–6.

Productus (Plicatifera) humerosus var. *longa* Paeckelmann, 1931, p. 128, pl. 9, fig. 1.

Productus (Plicatifera) humerosus var. *christiani* de Koninck. Paeckelmann, 1931, p. 131, pl. 10, fig. 1; pl. 12, fig. 4; pl. 13, fig. 1.

Levitusia humerosa (Sowerby). Muir-Wood and Cooper, 1960, pl. 109, figs. 2–5; pl. 110, figs. 1–5; Nalivkin and Fotieva, 1973, p. 43, pl. 9, figs. 4, 5; Garanj *et al.*, 1975, p. 181, pl. 78, fig. 2; pl. 80, fig. 5; Galitskaya, 1977, p. 123, pl. 12, figs. 4–7; pl. 38, fig. 1; Brunton, 1979, p. 7, pl. 1, figs. 1–6; pl. 2, figs. 1–5; pl. 4, figs. 1–4; Nalivkin, 1979, p. 59, pl. 18, fig. 6.

Levitusia christiani uralica Fotieva in Nalivkin and Fotieva, 1973, p. 44, pl. 10, figs. 1, 2.

Material.—One specimen from locality KAR11, external mould of a ventral valve, IGPS111744.

Description.—Shell large in size for genus, longer subrectangular in outline, widest slightly anterior to mid-length; length more than 45 mm, width more than 35 mm in the sole specimen (IGPS111744). Ventral valve strongly convex in lateral profile, roundly geniculated and followed by a long trail; sulcus broad and shallow on trail. External surface of ventral valve ornamented with irregular weak rugae on visceral portion and several strong longitudinal flutings on trail. Interior of the ventral

valve not preserved.

Remarks.—This specimen is poorly preserved, but can be referred to *Levitusia humerosa* (Sowerby, 1822), redescribed by Brunton (1979, p. 7, pl. 1, figs. 1–6; pl. 2, figs. 1–5; pl. 4, figs. 1–4) on the type specimens from the lower Viséan of Belgium and Staffordshire, England, in the large, strongly convex ventral valve, with long sulcated trail, and ornamented with irregular rugae on visceral portion and several strong longitudinal flutings on trail. *Levitusia sublaevis* (de Koninck, 1843), redescribed by Brunton (1979, p. 12, pl. 3, figs. 1–9; pl. 4, figs. 5, 6) from the lower Viséan of Belgium and Lancashire, England, differs from *L. humerosa* in having weaker posterior rugation and a shallower ventral sulcus.

Distribution.—Lower Viséan: northeastern Japan (Okuhinotsuchi in the South Kitakami Belt), UK (England), Belgium, Germany, western Russia (Donetz Basin), central Russia (western and southern Urals), Uzbekistan (Fergana) and Kyrgyzstan (northern Tian-Shan).

Order Spiriferida Waagen, 1883
Suborder Spiriferidina Waagen, 1883
Superfamily Spiriferoidea King, 1846
Family Spiriferidae King, 1846
Subfamily Spiriferinae King, 1846

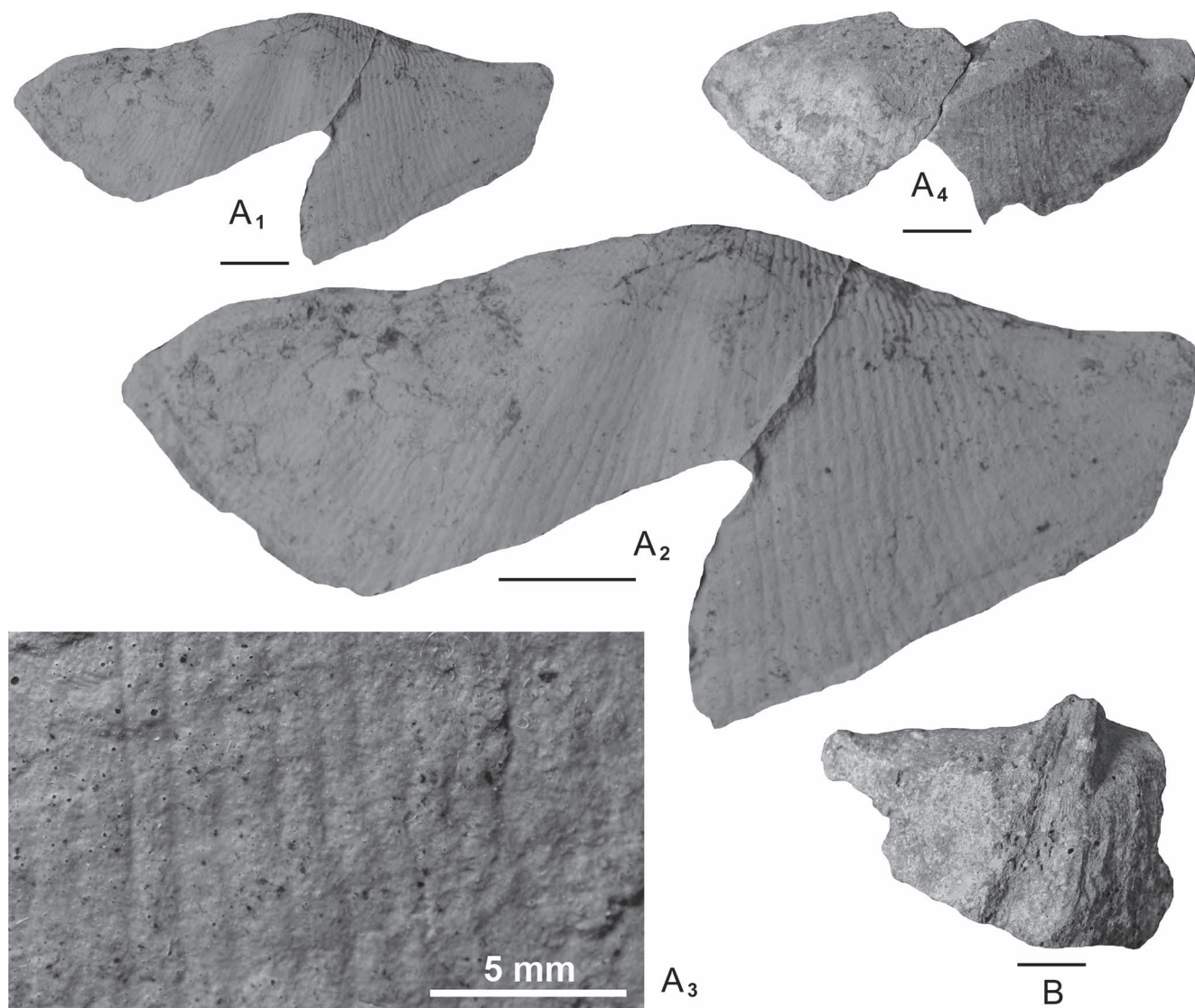


Figure 4. *Grandispirifer mylkensis* Yang from the Arisu Formation of Okuhinotsuchi. **A**, external latex cast (A₁, A₂, A₃) and internal mould (A₄) of ventral valve, IGPS111742, enlarged external latex cast of ventral valve (A₃) showing very fine growth lines over the ventral valve; **B**, internal mould of ventral valve, IGPS111743. Scale bars are 1 cm, except for A₃.

Genus *Grandispirifer* Yang, 1959

Type species.—*Grandispirifer mylkensis* Yang, 1959.

Grandispirifer mylkensis Yang, 1959

Figure 4

Grandispirifer mylkensis Yang, 1959, p. 113, 118, pl. 1, figs. 1, 2; pl. 2, figs. 1–3; Yang, 1964, p. 121, pl. 16, figs. 4, 5; pl. 17, figs. 1–3; text-figs. 18, 19; Zhang *et al.*, 1983, p. 350, pl. 121, fig. 1; Shi *et al.*, 2016, p. 586, figs. 4, 5A, B.

Spirifer subaequalis Hall. Yang *et al.*, 1962, p. 99, pl. 39, figs. 2, 3.

Material.—Two specimens from localities KAR4 and KAR6: (1) external and internal moulds of a ventral valve, IGPS111742; and (2) internal mould of a ventral valve, IGPS111743.

Description.—Shell medium in size for genus, transversely semicircular in outline, with greatest width slightly anterior to hinge, cardinal extremities rounded; length 36 mm, width 77 mm in the better preserved specimen (IGPS111742). Ventral valve moderately convex in lateral profile, most convex at umbonal region; umbo small, incurved; sulcus narrow and shallow, weakly developed. External surface of ventral valve ornamented with numerous simple and nearly flat costae, numbering

7–8 in 10 mm at anterior margin of valve, and very fine concentric growth lines over valve. Ventral interior with a large, heart-shaped muscle field. Other internal structures not preserved.

Remarks.—These specimens are referred to *Grandispirifer mylkensis* Yang, 1959, from the lower Visean of Mt. Borohoro, Xinjiang, northwestern China, in the large, transverse ventral valve with weakly developed sulcus and rounded cardinal extremities. Shells described by Yang *et al.* (1962, p. 99, pl. 39, figs. 2, 3) as *Spirifer subaequalis* (Hall) from the Chengqianggou Formation of the southern Qilianshan, Qinghai, northwestern China, are considered to be conspecific with the present species. *G. qaidamensis* Lee, Shi and Chen in Shi *et al.* (2016, p. 586, figs. 5C, 6, 7), from the upper part of the Huaitoutala Formation of Qinghai, northwestern China, is readily distinguished from *G. mylkensis* by its strongly transverse outline.

Distribution.—Upper Tournaisian–lower Visean: northeastern Japan (Okuhinotsuchi and Yokota in the South Kitakami Belt) and northwestern China (Xinjiang and Qinghai).

Acknowledgements

Sincere thanks are due to two anonymous reviewers for their valuable comments and suggestions on the manuscript; and Yousuke Ibaraki (Fossa Magna Museum, Itoigawa) for his help in drawing figures.

References

- Brunton, C. H. C., 1979: The Lower Carboniferous brachiopod genus *Levitusia* Muir-Wood, H. M. and Cooper, G. A., 1960 from western Europe and the U.S.S.R. *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique*, vol. 51, p. 1–23.
- Davidson, T., 1858–1863: *British Carboniferous Brachiopoda*, Vol. 2. *Permian and Carboniferous Species*, 280 p. Palaeontographical Society, London.
- Galitskaya, A. Ya., 1977: *Early and Middle Carboniferous Productids of Northern Kirgiz*, 297 p. Ilim, Frunze. (in Russian; original title translated)
- Garanj, I. M., Guseva, S. N., Devingtal, V. V., Donakova, L. M., Enokyan, N. V., Kalashnikov, N. V., Lapina, N. N., Mikhaylova, E. N., Nalivkin, D. V., Semichatova, S. V., Stepanov, D. L., Stepanova, G. A., Shestakova, M. F. and Einor, O. L., 1975: Brachiopoda. In, Stepanov, D. L., Krylova, A. K., Grozdnilova, L. P., Pozner, V. M. and Sultanaev, A. A. eds., *Palaeontological Atlas of the Carboniferous Deposits of the Urals*, p. 154–203. Nedra, Leningrad. (in Russian; original title translated)
- Kawamura, M., 1985a: Lithostratigraphy of the Carboniferous formations in the Setamai region, Southern Kitakami Belt, Northeast Japan (Part 1): Shimoarisu district of the Setamai Subbelt. *Journal of the Geological Society of Japan*, vol. 91, p. 165–178. (in Japanese with English abstract)
- Kawamura, M., 1985b: Lithostratigraphy of the Carboniferous formations in the Setamai region, Southern Kitakami Belt, Northeast Japan (Part 2): Yokota district of the Setamai Subbelt. *Journal of the Geological Society of Japan*, vol. 91, p. 245–258. (in Japanese with English abstract)
- Kawamura, T. and Kawamura, M., 1989: The Carboniferous System of the South Kitakami Terrane, Northeast Japan (Part 1): Summary of the stratigraphy. *Earth Science (Chikyū Kagaku)*, vol. 43, p. 84–97. (in Japanese with English abstract)
- King, W., 1846: Remarks on certain genera belonging to the class Palaeobranchiata. *Annals and Magazine of Natural History*, London, vol. 18, p. 26–42 and p. 83–94.
- Koninck, L. G. de, 1842–1844: *Description des Animaux Fossiles qui se Trouvent dans le Terrain Carbonifère de Belgique*, 650 p. H. Dessain, Liège.
- Minato, M., 1941: On the Lower Carboniferous deposits at Setamai, Kesen-gori, Iwate Prefecture. *Journal of the Geological Society of Japan*, vol. 48, p. 469–490. (in Japanese with English abstract)
- Minato, M., Hashimoto, S., Suyama, K., Takeda, H., Suzuki, Y., Kimura, S., Yamada, K., Kakimi, T., Ichikawa, T. and Suetomi, H., 1953: Biostratigraphie des Karbons im Kitakami-Gebirge, nordöstliches Honshu, Japan. *Journal of the Geological Society of Japan*, vol. 59, p. 385–399. (in Japanese with German abstract)
- Minato, M., Hunahashi, M., Watanabe, J. and Kato, M., 1979: *Variscan Geohistory of Northern Japan: Abean Orogeny*, 427 p. Tokai University Press, Tokyo.
- Minato, M. and Kato, M., 1979: Chapter 2f3. Biostratigraphy and correlation. In, Minato, M., Hunahashi, M., Watanabe, J. and Kato, M. eds., *Variscan Geohistory of Northern Japan: Abean Orogeny*, p. 80–81. Tokai University Press, Tokyo.
- Muir-Wood, H. M. and Cooper, G. A., 1960: Morphology, classification and life habits of the Productoidea (Brachiopoda). *Geological Society of America Memoir*, vol. 81, p. 1–447.
- Nalivkin, D. V., 1979: *Tournaisian Brachiopods of the Urals*, 248 p. Nauka, Leningrad. (in Russian; original title translated)
- Nalivkin, D. V. and Fotieva, N. N., 1973: *Brachiopods from the Boundary Beds of Tournaisian and Visean in the Western Slope of the Urals*, 118 p. Nauka, Moskva. (in Russian; original title translated)
- Onuki, Y., 1956: Geology of the Kitakami Mountains. In, Iwate Prefecture ed., *Explanatory Text of the Geology of Iwate Prefecture*, p. 1–189. Sasaki Printing and Publishing, Sendai. (in Japanese; original title translated)
- Onuki, Y., 1969: Geology of the Kitakami Massif, Northeast Japan. *Contributions from the Institute of Geology and Paleontology, Tohoku University*, no. 69, p. 1–239. (in Japanese with English abstract)
- Onuki, Y., 1981: The Kitakami Massif. In, Techno Hase Co., Ltd. ed., *Explanatory Text of the Geology of the Kitakami River Area (1: 200,000)*, p. 3–223. Toko Insatsu, Sendai. (in Japanese; original title translated)
- Paeckelmann, W., 1931: Die Fauna des deutschen Unterkarbons, 2. Teil: Die Productinae und *Productus*-ähnlichen Chonetinae. *Abhandlungen der Preussischen Geologischen Landesanstalt, Neue Folge*, vol. 136, p. 1–441.
- Rotai, A. P., 1931: Brachiopods and stratigraphy of the Lower Carboniferous of the Donetz Basin. *Izvestiya Glavnogo Geologo-Razvedochnogo Upravleniya*, vol. 73, p. 35–144. (in Russian with English summary)
- Rotai, A. P., 1941: Class Brachiopoda. In, Librovich, L. S. ed., *Atlas of Index Species of Fossil Fauna in the USSR, Vol. 4. Lower Carboniferous System*, p. 85–117. VSEGEI, Moskva. (in Russian; original title translated)
- Saito, Y., 1966: Geology of the Setamai district, southern Kitakami Massif, northeast Japan. *Contributions from the Institute of Geol-*

- ogy and Paleontology, Tohoku University, no. 62, p. 55–67. (in Japanese with English abstract)
- Saito, Y., 1968: Geology of the Younger Paleozoic System of the southern Kitakami Massif, Iwate Prefecture, Japan. *Science Reports of the Tohoku University, Second Series (Geology)*, vol. 40, p. 79–139.
- Sarytcheva, T. G. and Sokolskaya, A. N., 1959: On the classification of pseudopunctate brachiopods. *Doklady Akademii Nauk SSSR*, vol. 125, p. 181–184. (in Russian; original title translated)
- Shi, G. R., Chen, Z.-Q., Lee, S. and Zhan, L.-P., 2016: Early Carboniferous spiriferoid brachiopods from the Qaidam Basin, Northwest China: Taxonomy, biostratigraphy and biogeography. *Palaeoworld*, vol. 25, p. 581–599.
- Sowerby, J., 1821–1822: *The Mineral Conchology of Great Britain, Vol. 4*, 184 p. Published by the author, London.
- Takeda, H., 1960: Paleozoic formations in Shimoarisu village, southern Kitakami Massif, northeast Honshu, Japan. *Journal of the Geological Society of Japan*, vol. 66, p. 689–699. (in Japanese with English abstract)
- Tazawa, J., 1985: Carboniferous brachiopods *Marginatia* and *Unispirifer* from the Hikoroichi and Arisu formations, Kitakami Mountains, Northeast Japan. *Earth Science (Chikyu Kagaku)*, vol. 39, p. 459–462. (in Japanese with English title)
- Tazawa, J., 2002: Late Paleozoic brachiopod faunas of the South Kitakami Belt, northeast Japan, and their paleobiogeographic and tectonic implications. *Island Arc*, vol. 11, p. 287–301.
- Tazawa, J., 2006: The *Marginatia-Syringothyris-Rotaia* brachiopod assemblage from the Lower Carboniferous of the South Kitakami Belt, northeast Japan, and its palaeobiogeographical implications. *Paleontological Research*, vol. 10, p. 127–239.
- Tazawa, J., 2017: An early Carboniferous (late Visean) brachiopod fauna from Tairagai in the Yokota area, South Kitakami Belt, Japan. *Paleontological Research*, vol. 21, p. 329–346.
- Tazawa, J., 2018: Early Carboniferous (Mississippian) brachiopods from the Hikoroichi Formation, South Kitakami Belt, Japan. *Memoir of the Fukui Prefectural Dinosaur Museum*, no. 17, p. 27–87.
- Tazawa, J. and Iryu, Y., 2019: Early Carboniferous (early Visean) brachiopod fauna from the middle part of the Arisu Formation in the Shimoarisu area, South Kitakami Belt, Japan. *Paleontological Research*, vol. 23, p. 95–109.
- Tazawa, J., Itabashi, F. and Mori, K., 1981: Lower Carboniferous System in the Nisawa district, southern Kitakami Mountains, Japan. *Contributions from the Institute of Geology and Paleontology, Tohoku University*, no. 83, p. 21–37. (in Japanese with English abstract)
- Tazawa, J. and Katayama, T., 1979: Lower Carboniferous brachiopods from the Odaira Formation in the southern Kitakami Mountains. *Science Reports of the Tohoku University, Second Series (Geology)*, vol. 49, p. 165–173.
- Waagen, W., 1883: Salt Range fossils, 1. *Productus*-Limestone fossils: Brachiopoda. *Palaeontologia Indica, Series 13*, vol. 1, p. 391–546.
- Yang, F., 1994: Carboniferous. In, Yin, H. ed., *The Palaeobiogeography of China*, p. 131–162. Oxford University Press, New York.
- Yang, S., 1959: On the new Visean spiriferid genus *Grandispirifer*. *Acta Palaeontologia Sinica*, vol. 7, p. 111–120. (in Chinese and Russian)
- Yang, S., 1964: *Lower and Middle Carboniferous Brachiopods from the Northern Slope of Mt. Borochoro, Xinjiang, China, and Their Stratigraphical Significance*, 179 p. Science Press, Beijing. (in Chinese with Russian summary)
- Yang, S., 1980: The stratigraphical and geographical distribution of Fengninian brachiopods of China. *Geological Review*, vol. 26, p. 471–476. (in Chinese; original title translated)
- Yang, S., 1983: Palaeozoogeographic provinces of the Lower Carboniferous of China. In, Lu, Y. et al. eds., *Palaeobiogeographic Provinces of China*, p. 64–73. Science Press, Beijing. (in Chinese; original title translated)
- Yang, Z., Ting (Ding), P., Yin, H., Zhang, S. and Fang, J., 1962: Carboniferous, Permian and Triassic brachiopod faunas from the Chilianshan region. In, Institute of Geology and Paleontology, Geological Institute, Academia Sinica and Beijing University of Geology eds., *Monograph on Geology of the Chilianshan Mountains, Vol. 4, Part 4*, p. 1–129. Science Press, Beijing. (in Chinese; original title translated)
- Yanishevsky, M., 1918: Materials for the study of the Lower Carboniferous fauna of Fergana. *Trudy Geologicheskogo Komiteta, Novaya Seriya*, vol. 162, p. 1–145. (in Russian with English summary)
- Zhang, C., Zhang, F., Zhang, Z. and Wang, Z., 1983: Phylum Brachiopoda. In, Regional Geological Surveying Team of Xinjiang, Institute of Geoscience of Xinjiang, and Geological Surveying Group of Petroleum Bureau of Xinjiang eds., *Palaeontological Atlas of Northwest China; Xinjiang Autonomous Region, Part 2. Late Palaeozoic Volume*, p. 262–386. Geological Publishing House, Beijing. (in Chinese; original title translated)

Author contributions

J. T. initiated the study and wrote most of the manuscript, including the taxonomy. H. K. contributed to field work, studied the stratigraphy, and collected the fossils.