

Middle Permian brachiopods from the Dongujimqinqi area, Inner Mongolia, China

Jun-ichi TAZAWA*, Shuzhong SHEN** and Guang R. SHI**

Abstract

A small collection of brachiopods is described from the lower Middle Permian Yanchibeishan Formation of the Dongujimqinqi area, eastern Inner Mongolia, China. This fauna consists of the following four species: *Kochiproductus* sp., *Linoproductus simensis* (Tschernyschew), *Rhynchopora inconstantis* Lee and Gu and *Licharewia grewingki* (Netschajew). The Dongujimqinqi fauna exhibits a strong Boreal-type aspect and suggests an early Middle Permian in age.

Key words: Boreal-type fauna, Brachiopoda, Dongujimqinqi, Inner Mongolia, Middle Permian.

Introduction

Permian brachiopod faunas of Inner Mongolia are important and useful to reconstruct the Permian palaeogeography of east Asia, especially the Sino-Korean and Mongolian blocks and the interspaced area between them. Since the pioneering work of Grabau in 1931, the Permian brachiopods of Inner Mongolia have been described by Lee and Gu (1976), Lee et al. (1980, 1982, 1983, 1985), Liu and Waterhouse (1985), Gu and Zhu (1985) and Duan and Li (1985). However, these taxonomic works were concentrated on the faunas of both the Zhesi (Jisu) and Xiujimqinqi areas, and the other faunas, e.g., the Dongujimqinqi fauna have not been studied enough. The Permian palaeogeography and palaeobiogeography of Inner Mongolia were discussed by Lee and Gu (1984) and Tazawa (1991) on the basis of brachiopod faunas. They considered that the Dongujimqinqi fauna as a Boreal-type fauna. Lee and Gu (1984) mentioned that the Permian faunal provinciality in the Inner Mongolian region was controlled

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

** School of Ecology and Environment, Deakin University, Rusden Campus, 662 Blackburn Road, Clayton, Victoria 3168, Australia

(Manuscript received 30 November, 2000; accepted 21 December, 2000)

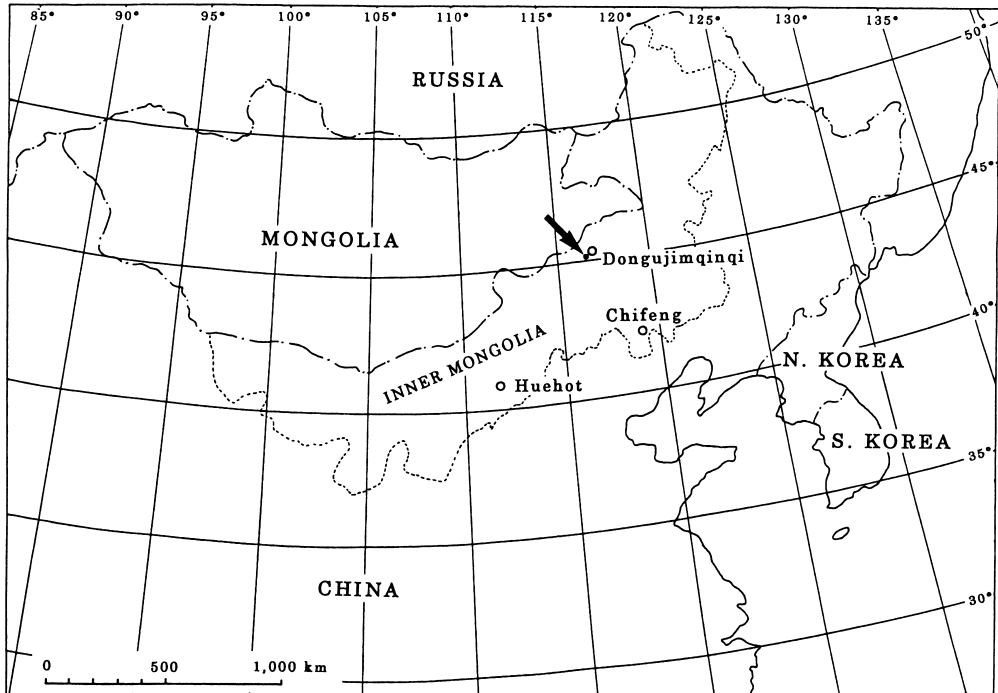


Fig. 1. Map showing the fossil locality (arrow).

by the topography and the sea current in that time, a view also advocated by Shi and Zhan (1996). On the other hand, Tazawa (1991) explained that the faunal provinciality in the Inner Mongolian region was caused by the plate tectonic motion during the Permian, namely the collision of Siberian (Mongolian) and Sino-Korean blocks in late Permian. According to him, the Dongujimqinqi area was a part of continental shelf bordering the southern margin of the Siberian (Mongolian) continent located at the middle palaeolatitude of Northern Hemisphere and characterized by the Boreal fauna in the Permian time.

The brachiopod fossils described here were collected by the China-Japan Cooperative Research Group (Leader: K. Ishii) in August 1988, from grey, fine-grained calcareous sandstone of the lower Middle Permian Yanchibeishan Formation (= Gegenaobao Formation of Lee and Gu, 1976) at the point 1638, about 32 km SW of Dongujimqinqi, eastern Inner Mongolia (Fig. 1). The Gegenaobao Formation is correlated with the upper Chihhsian (Sheng and Jin, 1994).

In the present study, the following four brachiopod species are recognized and described: *Kochiproductus* sp., *Linoproductus simensis* (Tschernyschew, 1902), *Rhynchopora inconstantis* Lee and Gu, 1976 and *Licharewia grewingki* (Netschajew, 1911). Among them, *Kochiproductus* sp., *Rhynchopora inconstantis* and *Licharewia grewingki* are all Boreal-type elements. *Linoproductus simensis* has a longer range from Early Carboniferous (Viséan) to Middle Permian (Chihhsian). But *R. inconstantis* was described from the lower Middle Per-

mian (Chihsian) of the Dongujimqinqi area, Inner Mongolia. Furthermore, *L. grewingki* has been known from lower Middle Permian of Inner Mongolia and northern Russia. Consequently the Dongujimqinqi fauna is an early Middle Permian (Chihsian) Boreal-type brachiopod fauna.

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

Systematic descriptions

Order Productida Sarytcheva and Sokolskaya, 1959

Suborder Productidina Waagen, 1883

Superfamily Productoidea Gray, 1840

Family Productidae Gray, 1840

Subfamily Buxtoniinae Muir-Wood and Cooper, 1960

Tribe Buxtoniini Muir-Wood and Cooper, 1960

Genus *Kochiproductus* Dunbar, 1955

Kochiproductus sp.

Figs. 2A-C.

Material. — Two incomplete ventral valves (NU-B167, 168) and an incomplete shell with conjoined valves (NU-B169).

Description. — Shell large for genus, more than 60 mm long and about 60 mm wide. Ventral valve moderately convex in lateral and anterior profiles; lateral slopes sharply inclined; sulcus deep and wide, originating from anterior part of visceral disc and developed on trail. Dorsal valve with a shallow concavity; fold inconspicuous. External ornament of both valves consisting of radial rows of numerous elongate spine bases and some irregular and discontinuous rugae. Dorsal interior with a very long fine median septum. Other characters unknown.

Remarks. — The present specimens are poorly preserved, but safely assigned to the genus *Kochiproductus* Dunbar, 1955 on the basis of their size, shape and surface ornament of the shells. These specimens most resemble the shells of *Kochiproductus* cf. *porrectus* (Kutorga, 1844), described by Grabau (1931, p. 295, pl. 30, figs. 10-12) and Duan and Li (1985, p. 109, pl. 36, figs. 1-4; pl. 37, figs. 1, 2) from the Middle Permian Zhesi Formation of the Zhesi area, Inner Mongolia, in having a rather deep sulcus and steep lateral slopes. The type species, *K. porrectus*, originally described by Kutorga (1844, pl. 10, figs. 3a, b) from the Lower Permian of the Urals, however, has a shallower sulcus, gently inclined lateral slopes, relatively pointed umbonal region and emarginate anterior margin, all of which are different from those of the Inner Mongolian specimens. The Dongujimqinqi specimens may be a new species, although the establishment is difficult for the poorly preserved material.

Superfamily Linoproductoidea Stehli, 1954

Family Linoproductidae Stehli, 1954

Subfamily Linoproductinae Stehli, 1954

Genus *Linoproductus* Chao, 1927*Linoproductus simensis* (Tschernyschew, 1902)

Figs. 2D-J.

1902 *Productus simensis* Tschernyschew, p. 286, 626, pl. 35, figs. 7a-c; pl. 55, figs. 2-5.

1908 *Productus cora* var. *simensis* Tschernyschew: Gröber, p. 220, pl. 25, figs. 2a, b.

1927 *Linoproductus simensis* (Tschernyschew): Chao, p. 137, pl. 14, figs. 6-8.

1960 *Linoproductus simensis* (Tschernyschew): Volgin, p. 72, pl. 8, figs. 1a-v.

1965 *Linoproductus simensis* (Tschernyschew): Zhao, p. 425, pl. 1, figs. 6, 7.

1971 *Linoproductus simensis* (Tschernyschew): Bamber and Waterhouse, pl. 16, figs. 8, 11.

1974 *Linoproductus simensis* (Tschernyschew): Sergunkova and Zhizhilo, p. 62, pl. 9, figs. 9, 10; pl. 10, figs. 8, 9.

1976 *Linoproductus simensis* (Tschernyschew): Lee and Gu, p. 258, pl. 139, figs. 9-12.

1976 *Linoproductus neimongolensis* Lee and Gu, p. 258, pl. 178, figs. 1-10.

1980 *Linoproductus simensis* (Tschernyschew): Lee et al., p. 376, pl. 152, figs. 11a, b.

Material.—Seven incomplete ventral valves (NU-B170-176) and a shell with broken ventral valve and a part of dorsal valve external mould (NU-B177).

Description.—Shell small for genus, elongate oval in outline, with greatest width at midvalve; length 34 mm, width 24 mm in the best preserved specimen (NU-B173). Hinge slightly narrower than greatest width of shell; ears small, well demarcated from visceral disc; cardinal extremities obtuse, angular; beak low and thick, strongly incurved to overhanging hinge. Ventral valve strongly convex in lateral profile, most convex at umbonal region, visceral disc globose, not geniculated and following a long, tube-shaped trail; umbonal and lateral slopes steep; sulcus absent. Dorsal valve moderately concave in lateral profile; having small ears and no fold. External ornament of ventral valve costellate; costellae numbering 10-12 per 5 mm at midvalve, commonly flexuous near frontal margin; rugae developed on ears and lateral slopes of visceral disc, numbering 5-6; spines or spine bases not preserved. External ornament of dorsal valve like those of ventral valve, but costellae being more flexuous; rugae irregularly developed on venter.

Remarks.—These specimens are referred to *Linoproductus simensis* (Tschernyschew, 1902), originally described by Tschernyschew (1902, p. 286, 626, pl. 35, figs. 7a-c; pl. 55, figs. 2-5) from the Schwagerina Limestone of the Ural Mountains. The most characteristic tube-like trail can be observed in our specimens (see Fig. 2I). *Linoproductus neimongolensis*

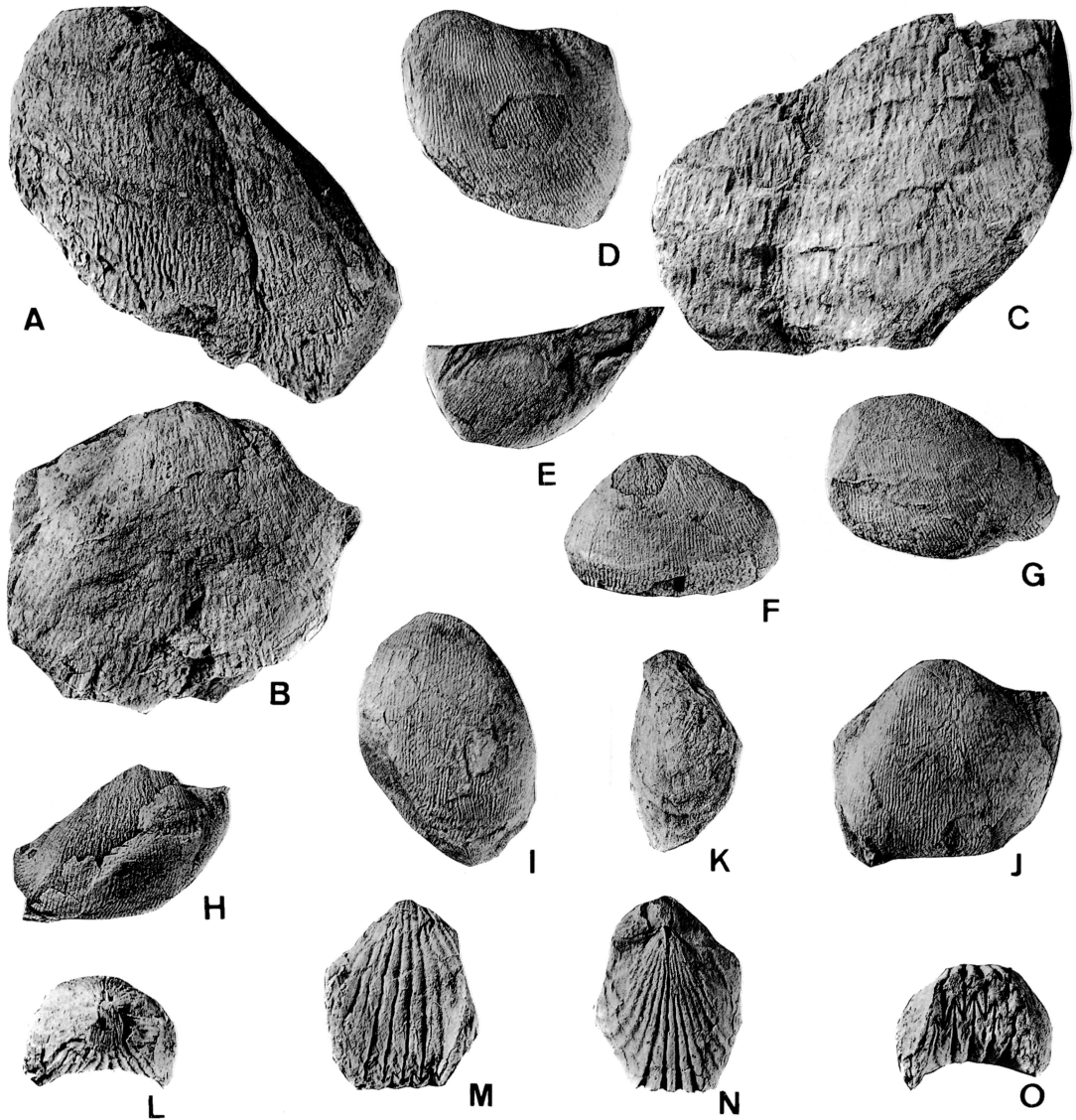


Fig. 2. A-C: *Kochiproductus* sp., A: NU-B169, incomplete shell in ventral view, B: NU-B168, incomplete ventral valve in ventral view, C: NU-B167, incomplete ventral valve in ventral view, D-J: *Linoproductus simensis* (Tschernyschew), D, E: NU-B173, incomplete ventral valve in ventral and posterior views, F: NU-B171, incomplete ventral valve in ventral view, G: NU-B176, incomplete ventral valve in ventral view, H: NU-B172, incomplete ventral valve in ventral view, I: NU-B173, incomplete ventral valve in ventral view, J: NU-B174, incomplete ventral valve in ventral view, K-O: *Rhynchopora inconstantis* Lee and Gu, NU-B178, internal mould of shell in lateral, posterior, ventral, dorsal and anterior views. All figures are in natural size.

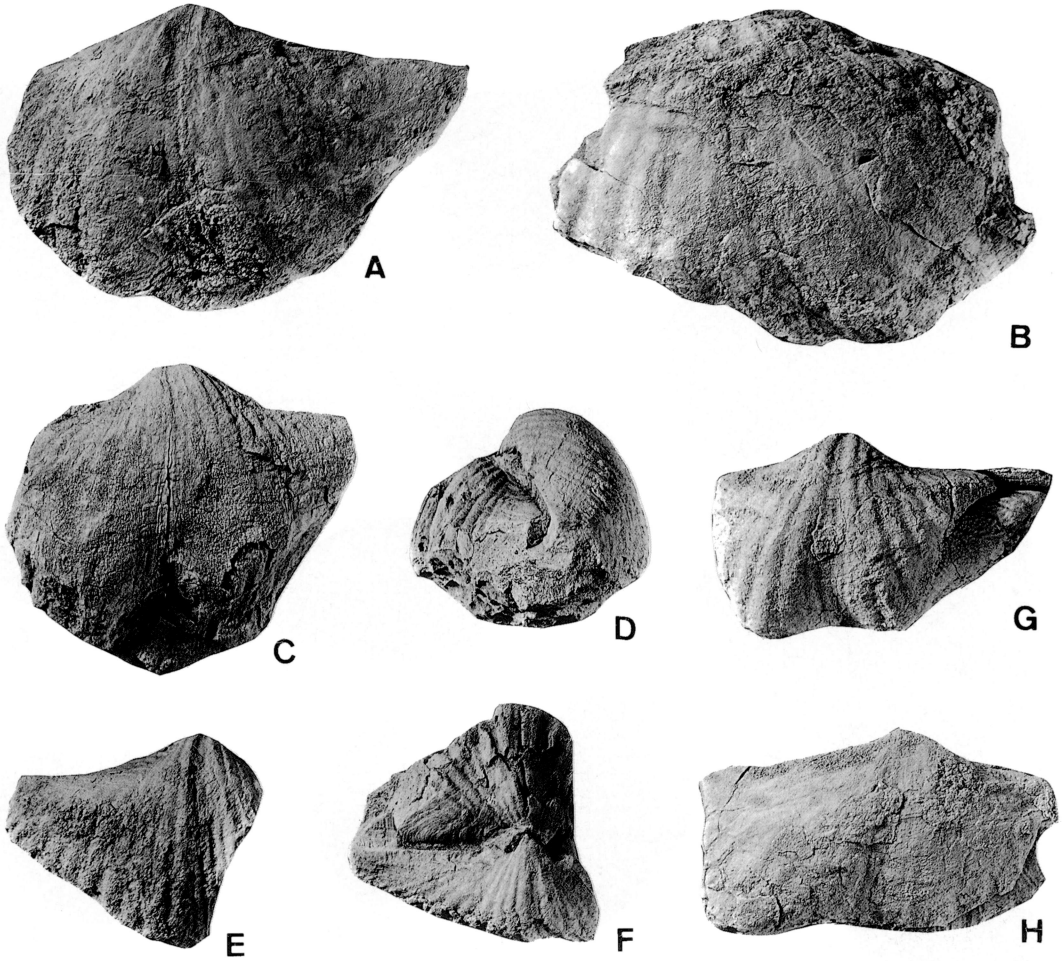


Fig. 3. A-H: *Licharewia grewingki* (Netschajew), A: NU-B180, incomplete ventral valve in ventral view, B: NU-B182, incomplete ventral valve in ventral view, C: NU-B179, incomplete ventral valve in ventral view, D-F: NU-B184, incomplete shell in lateral, ventral and posterior views, G: NU-B181, incomplete ventral valve in ventral view, H: NU-B183, incomplete shell in ventral view. All figures are in natural size.

Lee and Gu 1976, from the Lower Permian of the Dongujimqinqi region, Inner Mongolia seems to be conspecific with the present species.

Linoproductus tenuistriatus (Verneuil) differs from *L. simensis* in its finer costellae, more prominent rugae, and more flattened trail.

Distribution.—Lower Carboniferous (Visean) of Guizhou, south China; southern Tien Shan; Inner Mongolia. Upper Carboniferous (Kasimovian and Gzhelian) of southern Fergana; Inner Mongolia. Lower Permian (Asselian to Artinskian) of northern Yukon Territory; the Ural Mountains; southern Fergana. Middle Permian (upper Chihhsian) of Dongujimqinqi, Inner Mongolia.

Order Rhynchonellida Kühn, 1949
 Superfamily Rhynchoporoidea Muir-Wood, 1955
 Family Rhynchoporidae Muir-Wood, 1955
 Genus *Rhynchopora* King, 1865

Rhynchopora inconstantis Lee and Gu, 1976.

Figs. 3K-O.

1976 *Rhynchopora inconstantis* Lee and Gu, p. 274, pl. 184, figs. 1-7.

Material. — An internal mould of a shell with conjoined valves (NU-B178).

Description. — Shell large for genus, elongate subpentagonal in outline, with greatest width at about midvalve; length 28 mm, width 23 mm. Ventral valve gently convex in lateral profile; umbo acute, strongly incurved; sulcus shallow and wide; flanks narrow, highly elevated. Dorsal valve gently convex in lateral profile; umbo bluntly pointed and incurved; lateral slopes steep; fold low, wide, and gently elevated near anterior margin. External surface of both valves costate; costae strong and simple, beginning from beak, numbering 4 on bottom of sulcus, 2 on each sulcal slope and 5 on each flank, 5 on fold, and 6 on each lateral slope; intertroughs narrow. Ventral valve interior with slightly divergent dental plates of about 8 mm long. Dorsal valve interior with large triangular hinge plate; median septum strong, extending for about half length of dorsal valve, supporting a small camarophorium.

Remarks. — This specimen is safely assigned to the genus *Rhynchopora* King, 1865 in its rhynchonelliform shell, and having dental plates in the ventral valve and hinge plates and camarophorium supported by a strong median septum in the dorsal valve. The Dongujimqinqi specimen resembles well the shells of *Rhynchopora inconstantis* Lee and Gu, 1976, from the Middle Permian of Dongujimqinqi, Inner Mongolia, in large size, although the shape is longer than the type specimens.

Distribution. — Middle Permian (upper Chihhsian) of Dongujimqinqi, Inner Mongolia.

Order Spiriferinida Ivanova, 1972
 Suborder Spiriferinidina Ivanova, 1972
 Superfamily Syringothyridoidea Fredericks, 1926
 Family Licharewiidae Slussareva, 1958
 Genus *Licharewia* Einor, 1939

Licharewia grewingki (Netschajew, 1911)

Figs. 3A-H, 4.

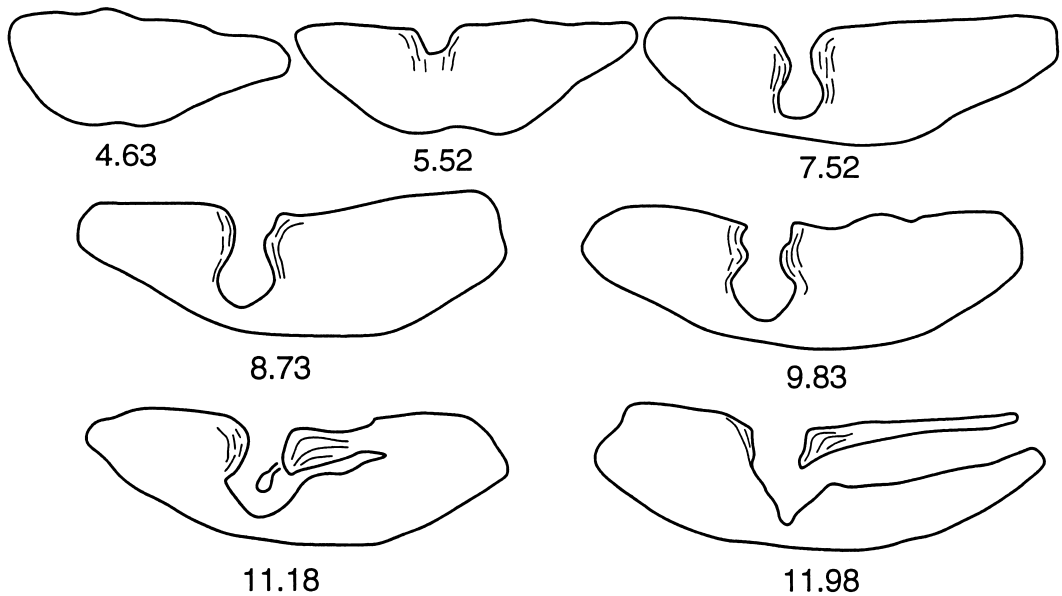


Fig. 4. Transverse serial sections of the ventral valve of *Licharewia grewingki* (Netschajew), NU-B179, $\times 1.5$. Numbers indicate distance (in mm) from the umbo.

1911 *Spirifer grewingki* Netschajew, p. 81, 149, pl. 10, figs. 1a-d.

1959 *Licharewia grewingki* (Netschajew): Kaschirzew, p. 63, pl. 30, figs. 1-3.

1960 *Licharewia grewingki* (Netschajew): Slussareva, p. 55, pl. 7, figs. 4-6.

1976 *Licharewia grewingki* (Netschajew): Lee and Gu, p. 278, pl. 174, figs. 6a, b; pl. 177, figs. 8a, b.

1998 *Licharewia? grewingki* (Netschajew): Kalashnikov, p. 45, pl. 5, figs. 1-3; pl. 6, figs. 1-3; pl. 7, figs. 1a, b; text-fig. 4.

Material. — Four incomplete ventral valves (NU-B179-182) and two incomplete shells with conjoined valves (NU-B183, 184).

Description. — Shell large for genus, transversely subelliptical in outline, widest at hinge; cardinal extremities blunt, produced; length about 42 mm, width about 81 mm in one adult specimen (NU-B180). Ventral valve beak thick and bluntly acute, moderately incurved; apical angle 115-120°; interarea low, broadly triangular, and slightly concave; flanks gently inclined; sulcus deep, with three fine sulcicostae, originating from beak, and widening and deepening anteriorly. External ornament of both valves costate; each flank of both valves with about 10 strong, simple costae; micro-ornamentation consisting of fine concentric lirae. Ventral interior with a pair of dental plates; dental plates very short, fused within top valve wall in apical cavity, becoming isolated ridges anteriorly; muscle trough deep. Other internal structures not observed.

Remarks.—These specimens are referred to *Licharewia grewingki* (Netschajew, 1911), originally described by Netschajew (1911, p. 81, 149, pl. 10, figs. 1a-d) from the Middle Permian (Kazanian) of the Pinega River region, northern European Russia.

Licharewia stuckenbergi (Netschajew, 1900), the type species of this genus, differs from *L. grewingki* in its smaller, more transverse shell, and weaker and more numerous costae on both valves.

Licharewia schrenckii (Keyserling, 1846) is distinguished from *L. grewingki* by its higher interarea of the ventral valve.

Distribution.—Middle Permian (upper Chihshian and Maokouan) of Abagqi and Dongujimqinqi, Inner Mongolia. Middle Permian (Lower Kazanian) of the Pinega River region, Pritiman and Kanin Peninsula, northern Russia; Omolon region, northeastern Russia.

Acknowledgements

J. Tazawa wishes to thank Dr. K. Ishii and the other members of the China-Japan Cooperative Research Group who helped him in the field, contributing substantially to the fossil collection and to understanding of the stratigraphy of the Dongujimqinqi region, Inner Mongolia. G.R. Shi wishes to acknowledge the Australian Research Council for financial support to this study (Grant A39701265).

References

- Bamber, E.W. and Waterhouse, J.B., 1971, Carboniferous and Permian stratigraphy and paleontology, northern Yukon Territory, Canada. *Bull. Canad. Petr. Geol.*, **19**, 29-250.
- Chao, Y.T., 1927, Productidae of China, Pt. 1, Producti. *Palaeontologia Sinica, Ser. B*, **5**, 1-244.
- Duan, C. and Li, W., 1985, Descriptions of fossils; Phylum Brachiopoda. In Ding, Y., Xia, G., Duan, C. and Li, W., Study on the Early Permian stratigraphy and fauna in Zhesi district, Nei Mongol Zizhiqu (Inner Mongolia). *Bull. Tianjin Inst. Geol. Min. Res., Chin. Acad. Geol. Sci.*, **10**, 99-145, 199-214. (in Chinese).
- Dunbar, C.O., 1955, Permian brachiopod faunas of central East Greenland. *Meddel. om Grønland*, **110**, 1-169.
- Einor, O.L., 1939, Brachiopody nizhney permi Taymyra. *Tr. Arkt. Nauch.-Issledov. Inst.*, **135**, 1-150. (in Russian).
- Fredericks, G.N., 1926, *Tablitsa dlya opredeleniya rodov semeystva Spiriferidae King*. Izvestiya, Leningrad, 393-423. (in Russian).
- Grabau, A.W., 1931, The Permian of Mongolia: A report on the Permian fauna of the Jisu Honguer Limestone of Mongolia and its relations to the Permian of the other parts of the world. In Reeds, C.A., ed., *Natural History of Central Asia, Vol. 4.*, Amer. Mus. Nat. Hist., New York, 1- 665.
- Gray, J.E., 1840, *Synopsis of the contents of the British Museum, 42nd edition*. London, 370 p.
- Gröber, P., 1908, Ueber die Faunen des untercarbonischen Transgressionsmeeres des zentralen Tian-Schan, die in der Umgebung des Sart-dschol-Passes gefunden worden sind. *Neu. Jahrb. Min. Geol. Paläont.*, **26**, 213-248.
- Gu, F. and Zhu, R.F., 1985, Lower Permian brachiopods from Lin-Dong, Nei Mongol. *Bull.*

- Shenyang Inst. Geol. Min. Res., Chin. Acad. Geol. Sci.*, **12**, 74-97. (in Chinese).
- Ivanova, E.A., 1972, Osnovnye zakonomernosti evolyutsii spiriferid (Brachiopoda). *Paleont. Zhurnal*, 1972, no. 3, 28-42. (in Russian).
- Kalashnikov, N.V., 1998, *Spiriferidy permi evropeyskogo severa Rossii*. Geos, Moskva, 138 p. (in Russian).
- Kaschirzew, A.S., 1959, *Polevoy atlas fauny permskikh otlozheniy severo-vostoka SSSR*. Izd. Akad. Nauk SSSR, Moskva, 85 p. (in Russian).
- Keyserling, A.G., 1846, *Wissenschaftliche Beobachtungen auf einer Reise in das Petschora-Land, im Jahre 1843*. Carl Kray, St. Petersburg, 406 p.
- King, W., 1865, Remarks of the histology of two specimens of *Rhynchopora geinitziana* de Verneuil, from near the River Oukhla, Province of Archangel. *Ann. Mag. Nat. Hist., London, Ser. 3*, **16**, 124-128.
- Kutorga, S.S., 1844, Zweiter Beitrag zur Paläontologie Russlands. *Verh. Russ.-Kais. Min. Ges. St. Petersburg*, 62-104.
- Kühn, O., 1949, *Lehrbuch der Paläozoologie*. Stuttgart, 326 p.
- Lee, L. and Gu, F., 1976, Carboniferous and Permian Brachiopoda. In Geological Bureau of Nei Mongol and Geological Institute of Northeast China, eds., *Palaeontological atlas of Northeast China; Nei Mongol, Pt.1, Palaeozoic volume*, Geol. Pub. House, Beijing, 228-306. (in Chinese).
- Lee, L. and Gu, F., 1984, The paleogeographic outline and depositional characters of the early stages of Early Permian in Nei Mongol (Inner Mongolia)—Jilin subregion. *Bull. Chin. Acad. Geol. Sci.*, **8**, 107-121. (in Chinese).
- Lee, L., Gu, F. and Li, W., 1982, A new genus and some new species of brachiopod from Lower Permian of Xi Ujimqin Qi, Nei Mongol. *Bull. Shenyang Inst. Geol. Min. Res., Chin. Acad. Geol. Sci.*, **4**, 113-129. (in Chinese).
- Lee, L., Gu, F. and Li, W., 1983, Early Permian productids from Xi Ujimqin Qi, Nei Mongol Autonomous. *Prof. Pap. Strat. Palaeont.*, **11**, 71-82. (in Chinese).
- Lee, L., Gu, F. and Li, W., 1985, *Spiriferella* and *Spiriferelloides* (Brachiopoda) from the Lower Permian of Xi Ujimqin Qi region, Inner Mongolia. *Prof. Pap. Strat. Palaeont.*, **12**, 121-139. (in Chinese).
- Lee, L., Gu, F. and Su, Y., 1980, Carboniferous and Permian Brachiopoda. In Shenyang Institute of Geology and Mineral Resources, eds., *Palaeontological atlas of Northeast China, Pt. 1, Palaeozoic volume*, Geol. Pub. House, Beijing, 327-428. (in Chinese).
- Liu, F. and Waterhouse, J.B., 1985, Permian strata and brachiopods from Xiujimqinqi region of Neimongol (Inner Mongolia) Autonomous Region. *Papers, Dept. Geol., Univ. Qd.*, **11**, 1-44.
- Muir-Wood, H.M., 1955, *A history of the classification of the phylum Brachiopoda*. Brit. Mus. (Nat. Hist.), London, 124 p.
- Muir-Wood, H.M. and Cooper, G.A., 1960, Morphology, classification and life habits of the Productoidea (Brachiopoda). *Geol. Soc. Amer., Mem.*, **81**, 1-477.
- Netschajew, A.V., 1900, Pervoe dopolnenie k faune permskikh otlozheniy vostochnoy polosity Evropeyskoy Rossii. *Tr. Geol. Kom.*, **34**, 1-44. (in Russian).
- Netschajew, A.V., 1911, Fauna permskikh otlozheniy vostoka i kraynyago severa Evropeyskoy Rossii. *Tr. Geol. Kom., Nov. Ser.*, **61**, 1-164. (in Russian).
- Sarytcheva, T.G. and Sokolskaya, A.N., 1959, O klassifikatsin lozhnoporistykh brachiopod. *Doklady, Akad. Nauk SSSR*, **125**, 181-184. (in Russian)
- Sergunkova, O.I. and Zhizhilo, O.R., 1974, Brachiopody srednego karbona, verkhnego karbona i nizhney permi Fergany. In Khodanovich, R.L. ed., *Biostratigrafiya verkhnego paleozoya gornogo obramleniya Yuzhnoy Fergany*, Izdvo. "Fan" Uz SSSR, Tashkent, 54-77. (in Russian).

- Sheng, J and Jin, Y., 1994, Correlation of Permian deposits in China. *Palaeoworld*, no. 4, 14-113.
- Shi, G.R. and Zhan, L.P., 1996, A mixed mid-Permian marine fauna from the Yanji area, northeastern China: A paleobiogeographical reinterpretation. *The Island Arc*, **5**, 386-395.
- Slussareva, A.D., 1958, O Kazanskikh spiriferakh. *Doklady, Akad. Nauk SSSR*, **118**, 581-583. (in Russian).
- Slussareva, A.D., 1960, Spiriferidy kazanskogo yarusa Russkoy platformy i usloviya ikh suschestvovaniya (rody *Licharewia* Einor i *Permospirifer* Kulikov). *Tr. Paleont. Inst.*, **80**, 1-120. (in Russian).
- Stehli, F.G., 1954, Lower Leonardian Brachiopoda of the Sierra Diablo. *Bull. Amer. Mus. Nat. Hist.*, **105**, 263-358.
- Tazawa, J., 1991. Middle Permian brachiopod biogeography of Japan and adjacent regions in East Asia. In Ishii, K., Liu, X., Ichikawa, K. and Huang, B., eds., *Pre-Jurassic geology of Inner Mongolia, China: Report of China-Japan Cooperative Research Group, 1987-1989*, Matsuya Insatsu, Osaka, 213-230.
- Tschernyschew, Th., 1902, Verkhnekamennougolnye brachiopody Urala i Timana. *Tr. Geol. Kom.*, **16**, 1-749. (in Russian).
- Volgin, V.I., 1960, *Brachiopody verkhnekamennougolnykh i nizhneperskikh otlozheniy Yuzhnoy Fergany*. Izdvo. Leningrad. Univ., Leningrad, 203 p. (in Russian).
- Waagen, W., 1883, Salt Range fossils, 1, Productus-Limestone fossils. *Palaeontologia Indica, Ser. 13*, **1**, 391-546.
- Zhao, Z., 1965, Upper Carboniferous brachiopods from Inner Mongolia. *Acta Palaeontologia Sinica*, **13**, 420-454. (in Chinese).