

SOME SPIRIFERID BRACHIOPODS FROM THE PERMIAN OF TIMOR (INDONESIA)

COR F. WINKLER PRINS

Nationaal Natuurhistorisch Museum, Postbus 9517, 2300 RA Leiden, The Netherlands.

WINKLER PRINS, C. F., 2008. Some spiriferid brachiopods from the Permian of Timor (Indonesia). *Proceedings of the Royal Society of Victoria* 120(1): 389–400. ISSN 0035-9211.

The study of neospiriferine and spiriferidine brachiopods from the Permian of Timor (Indonesia) present in the collections of the Nationaal Natuurhistorisch Museum (National Museum of Natural History, Leiden, The Netherlands) resulted in a revision of the species *Spirifer timorensis* Martin, 1881 and *Crassispirifer broilii* Waterhouse, 2004 and the description of a new species, *Latispirifer archboldorum* sp. nov. Also, a new genus, *Archboldiella*, is created, based on the aberrant species *Spirifer basleoensis* Hayasaka & Hosono, 1951.

Key words: Spiriferida, Permian, Timor, Indonesia.

SOME neospiriferine and spiriferidine brachiopods from the Permian of Timor (Indonesia) stored in the collections of the Nationaal Natuurhistorisch Museum at Leiden (The Netherlands) have been revised, and some additional specimens from the Artis Geologisch Museum (Amsterdam, The Netherlands) have been studied. It should be noted that negotiations are underway to transfer the collections of Artis Geologisch Museum to the Nationaal Natuurhistorisch Museum at Leiden. The Museum in Leiden houses amongst others the important collection of Molengraaff, partly described by Broili (1916) and Hamlet (1928). This collection was formerly housed at the museum of Delft Technical University and recently donated to the Nationaal Natuurhistorisch Museum (see Winkler Prins, 2004). The neospiriferine material was put apart for further study by Neil Archbold and me when he visited the Nationaal Natuurhistorisch Museum in 2005 after the V International Brachiopod Congress at Copenhagen and we both visited the Artis Geologisch Museum in Amsterdam. It should have formed the basis for our first joint paper under the auspices of our project 'Permian brachiopods from Timor'. His untimely demise prevented this, however.

Unfortunately, the exact locality and age cannot be ascertained for the old collections from the Permian of Timor since the material was generally bought by the basket load from the local inhabitants. However, an age indication can be given for certain (brachiopod) localities, as provided by Archbold in Charlton et al. (2002).

SYSTEMATICS

In the following section I have used the classification of Waterhouse (2004), taking the revised *Treatise of Invertebrate Paleontology* (Carter 2006) also into consideration.

Registration numbers prefixed RGM belong to the old collections of the Nationaal Natuurhistorisch Museum, whilst those prefixed THD are from the newly acquired collections of the museum of Delft Technical University, now also belonging to the aforementioned museum. For measurements see Table 1.

Subphylum RHYNCHONELLIFORMEA Williams, Carlson, Brunton, Holmer & Popov, 1996
Class RHYNCHONELLATA Williams, Carlson, Brunton, Holmer & Popov, 1996
Order SPIRIFERIDA Waagen, 1883
Suborder SPIRIFERIDINA Waagen, 1883
Superfamily SPIRIFEROIDEA King, 1846
Family NEOSPIRIFERIDAE Muir-Wood & Cooper, 1960

Subfamily FUSISPIRIFERINAE Waterhouse, 2004

Genus **Crassispirifer** Archbold & Thomas, 1985

Type species. *Spirifer rostalinius* Hosking, 1931.

Diagnosis. Shell moderate to large, transverse to subrectangular, may be strongly transverse and even alate in early ontogeny; fold (fastigium) and sulcus prominent; ornament consisting of numerous subequidimensional costae, which bifurcate and trifurcate; plicae and fasciculation weakly to moderately developed, one or two pairs of plicae in sulcus and on

Table 1. Measurements in mm of the described species, type specimens indicated with an asterix. L = length, W = width, Ls = surface length, Hi = height interarea of pedicle valve, Li = length interarea.

specimen	L	½W	H	Ls	Hi	½Li	costae/ 5mm	½ No. of plicae
<i>Crassispirifer timorensis</i>								
RGM 12040*	38.5	31	40	>56	6	28	6–7	7
RGM 15845	38	30	31	63	>3.5	26	7	5
<i>Crassispirifer cf. timorensis</i>								
THD 12473	25	19	15	40	3	18	7	5
<i>Crassispirifer broilii</i>								
Broili (1916, pl.120: 11)*	31	30	-	-	-	-	-	6
THD 2650	59	54	46	100	8.5	>45	7	6
<i>Latispirifer archboldorum</i>								
THD 12476*	52	67	40	75	6.5	>65	9	7
THD 12748	57	83	-	>70	-	83	9	8
THD 12474*	44	>46	37.5	83	4	35	9	5
L8519a (Artis Geol. Mus.)	49	51	37	80	c.4	>42	9	7
L8519b (Artis Geol. Mus.)	47	52.5	35	80	-	>42	9	6

fold, no plicae on ears; micro-ornamentation of fine capillae and small growth lamellae. Delthyrial plates weakly developed or absent.

Discussion. The genus *Crassispirifer* is distinguished by its micro-ornamentation of fine capillae and small growth lamellae and the presence of plicae in the sulcus. It differs from *Fusispirifer* (Waterhouse, 1966) by the presence of plicae in the sulcus and becoming less transverse during ontogeny and from *Transversaria* (Waterhouse & Gupta, 1983) also by its high fold and deep sulcus (see Archbold & Thomas, 1985). It is less transverse than *Latispirifer*, which apparently has no capillae. The diagnosis of the genus has been extended so as to include *Spirifer timorensis*, which shows no delthyrial plates.

Crassispirifer Abramov & Grigorieva, 1986 is a junior synonym and was renamed *Doescherella* by Abramov & Grigorieva (1987).

Distribution. Permian of Australasia: Pakistan, Western Australia, Timor (Indonesia), and Russia.

***Crassispirifer timorensis* (Martin, 1881)**

Fig. 1A-F.

Spirifer Moosakhailensis Dav. – Beyrich, 1865: 77, pl. 1, fig. 7.

pars Spirifer timorensis nov. spec. – Martin, 1881: 41, pl. 2, fig. 7; non fig. 8.

pars Spirifer timorensis nov. spec. – Martin, 1882: 112, pl. 2, fig. 7; non fig. 8.

pars Spirifer fasciger Keys. – Pannekoek, 1931: 419 footnote 1 (non cet.).

Neospirifer timorensis (Martin, 1881) – Archbold & Thomas, 1986: 136.

Neospirifer timorensis (Martin, 1881) – Archbold & Bird, 1989: fig. 6B-E.

Neospirifer timorensis (Martin, 1881) – Winkler Prins, 1989: fig. 34.

Material. Lectotype RGM 12040 (Martin 1881: pl. 2, fig. 7; see Archbold & Thomas, 1986, p. 136; Fig. 1A-C), collected by Dr C.F.A. Schneider from Kali Mati near Kupang (Amarassi region and therefore probably of late Wuchiapingian age; see Archbold in Charlton et al., 2002: 741); a specimen from Nefotassi (RGM 15845), probably of a similar (Kungurian-Ufimian) age as the Bitauai brachiopods, collected by Dr H.J.W. Jonker during the second Dutch Timor expedition (Fig. 1D-E). The second specimen figured by Martin (1881: pl. 2, fig. 8; RGM 12041) is not considered conspecific nor congeneric (see below).

A specimen from Bitauai (THD 12473, Molen-graaff collection; Fig. 1F), is considered a possible young individual (see below) and is classified as *Crassispirifer cf. timorensis*. However, its moderate size is considered by Archbold (op. cit.) to be typical for the Bitauai spiriferids, which are presumably of Kungurian-Ufimian age.

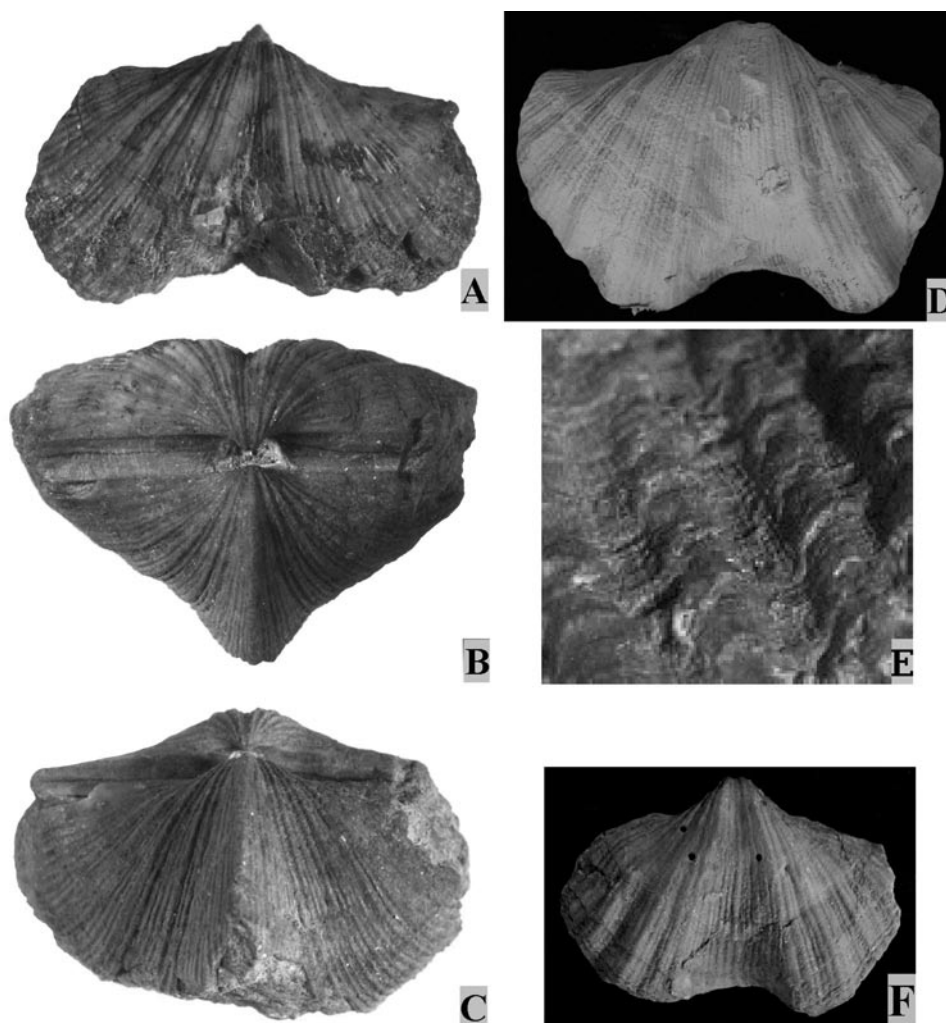


Fig. 1. A-E: *Crassispirifer timorensis* (Martin, 1881). A-C, Lectotype (RGM 12040, collection Schneider), Kali Mati near Kupang, probably late Wuchiapingian (see also Martin 1881/1882: pl. 2, fig. 7; Archbold & Bird 1989: fig. 6B-E); A: ventral view, x 1. B, posterior view, x 1. C, dorsal view, x 1. D-E, specimen from Nefotassi (RGM 15845, collection Jonkers) probably of Kungurian-Ufimian age. D, ventral view, x 1. E, part of the surface of the pedicle valve showing the growth lamellae and capillae, x 15. F: *Crassispirifer* cf. *timorensis* (Martin, 1881) (THD 12473, collection Molengraaff, Bitauani, probably of Kungurian-Ufimian age; see also Broili, 1916: pl. 120, fig. 12); ventral view, x 1, note the numerous borings (identified as *Oichmus simplex* Bromley, 1981 by Dr S.K. Donovan) not shown by Broili.

Diagnosis. Medium-sized, subquadrate species of *Crassispirifer* with globose brachial valve and more gently convex pedicle valve; fold and sulcus prominent, V-shaped. Ornamentation of fine, equidimensional costae, which bifurcate and trifurcate, forming fasciculae on up to 7 plicae on either side, which become less pronounced towards the lateral margins; the innermost plicae become incorporated in the sulcus/fold anteriorly; prominent central costa in the

sulcus; micro-ornamentation of fine capillae and small growth lamellae. Delthyrial plates absent.

Description. Medium-sized shells (for some measurements see Table 1) with a subquadrate outline. Pedicle valve gently convex with deep, V-shaped sulcus; interarea high ($H = c. 5$ mm), subrectangular, with open delthyrium. Brachial valve globose at maturity, with prominent, V-shaped fold; interarea narrow ($H = c.$

2 mm). Ornamentation of fine, equidimensional costae, which bifurcate and trifurcate, forming fasciculae on up to 7 plicae on either side, which become less pronounced towards the lateral margins; the innermost plicae become incorporated in the sulcus/fold anteriorly; prominent central costa in the sulcus; micro-ornamentation of fine capillae, *c.* 9 per mm (not seen on the holotype because the surface ornamentation is too poorly preserved, but visible on the specimens from Nefotassi and Bitauai, see Fig. 1E), and small growth lamellae, 3 per mm.

Internal structure unknown.

Comparison. From the other species assigned to *Crassispirifer* by Archbold & Thomas (1985) this species is distinguished by its subquadrate shape, its globose brachial valve, prominent fasciculation, the prominent central costa in the sulcus of the pedicle valve and the absence of delthyrial plates.

Comments. The second specimen assigned by Martin (1881: pl. 2, fig. 8; 1882: pl. 2, fig. 8) to his new species *Spirifer timorensis*, and thus originally a synonym, is not a *Crassispirifer* and obviously does not belong to this species (see also Archbold & Thomas,

1985); it could be a *Spiriferella* (see Fig. 2A-B). A specimen from Nefotassi (RGM 15845; Fig. 1D-E), on the other hand, is closely comparable and here assigned to this species, although it differs in having a less sharp fold and sulcus, more like a specimen figured by Broili (1916, pl. 120, fig. 13). It shows the micro-ornamentation of fine capillae (not observed on the holotype) and small growth lamellae.

The specimens from Bitauai figured by Broili (1916: pl. 120, figs. 12–13) are closely comparable in ornamentation to Martin's species, but they are much less globose. The specimen of fig. 12 (THD 12473; Fig. 1F) is also smaller with a weakly convex brachial valve, but does show a prominent median costa and could be a young specimen that had died early (possibly due to the numerous (gastropod?) borings, identified as *Oichnus simplex* Bromley, 1981 by Dr S.K. Donovan); it is identified as *Crassispirifer cf. timorensis* (Martin, 1881). The other specimen, depicted on fig. 13a-b, should have been part of the Molengraaff collection at Delft Technical University, but it could not be found in the collection and the specimen registered as such (THD 12474, with a label stating '*Spirifer fasciger* Keyserling, Bitauai, Broili, 1916, pl. 120, fig. 13') is quite distinct and here assigned to the new species *Latispirifer archboldorum* (Fig. 6A-C); it may not even be from Bitauai. The original specimen is either lost or mixed up with the Wanner material at Bonn (Germany). The other specimens figured by Broili (1916) as *Spirifer fasciger* Keys. show little or no resemblance to *Crassispirifer timorensis*: the specimen depicted on Broili's pl. 120, fig. 11 is the holotype of *Crassispirifer broilii* Waterhouse, 2004, the one of pl. 121, fig. 1 was assigned doubtfully by Waterhouse (2004) to that species, whilst those of pl. 121, figs. 2–3 are described below as a new species, *Latispirifer archboldorum*.

***Crassispirifer broilii* Waterhouse, 2004**

Fig. 3A-C.

pars Spirifer fasciger Keyserling – Broili, 1916: 37, pl. 120, figs. 10?, 11, 13?; 121, fig. 1? (non cet.).

pars Spirifer fasciger Keyserling – Hamlet, 1928: 38.

pars Crassispirifer broilii Waterhouse, 2004: 155–157.

Holotype. Bonn: internal mould (Broili, 1916: pl. 120, fig. 11).

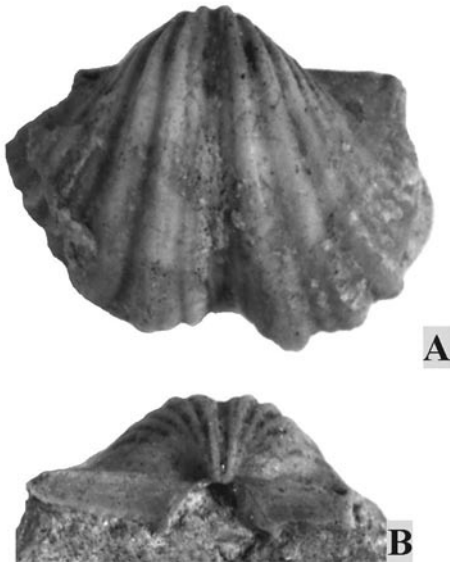


Fig. 2. A-B: *Spiriferella?* sp., pedicle valve (RGM 12041) originally described as a youthful specimen of *Spirifer timorensis* nov. spec. by Martin (1881: 42, pl. 2, fig. 8; also in 1882: 113, pl. 2, fig. 8), collection Schneider, Kali Mati near Kupang, probably late Wuchiapingian. A, ventral view x 2. B, posterior view x 2.

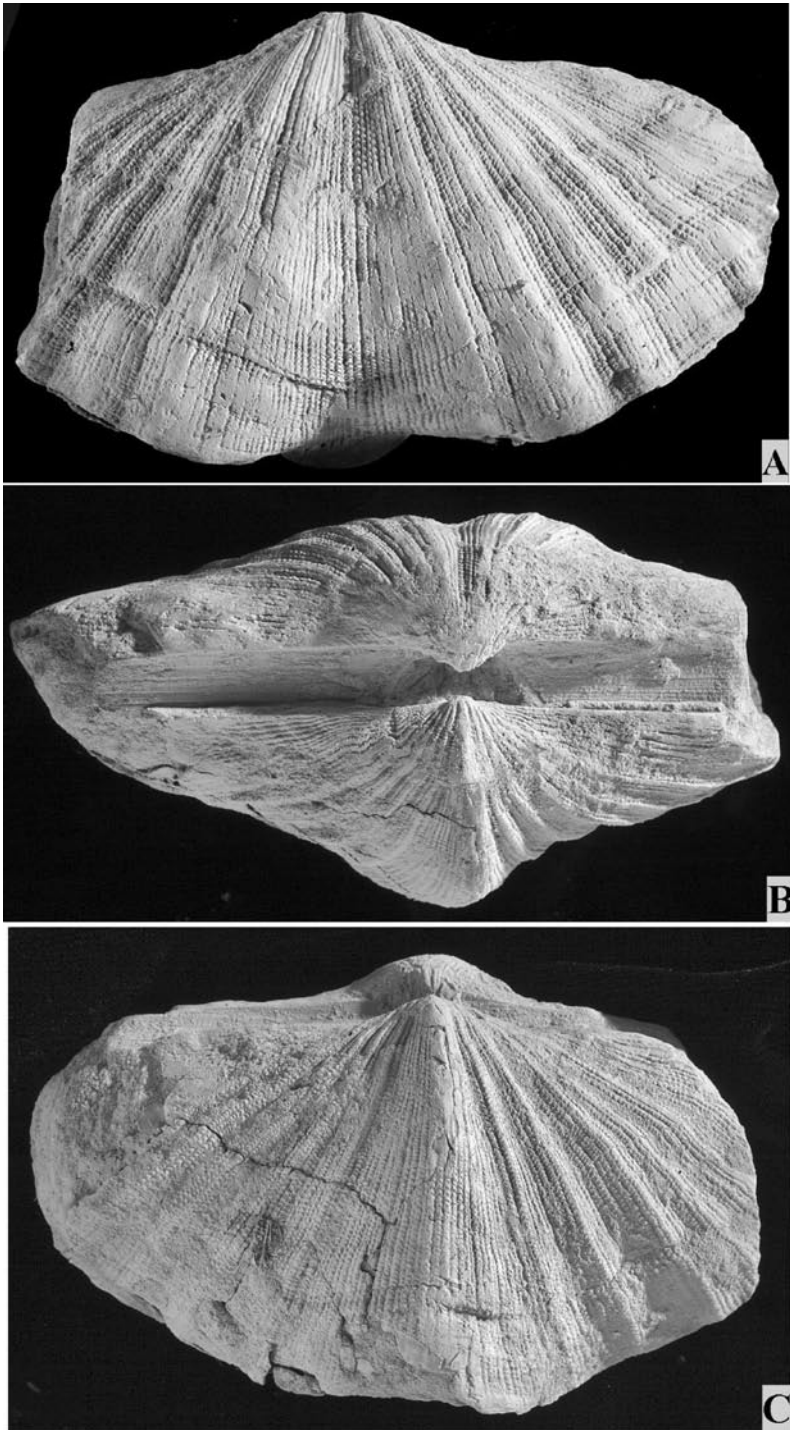


Fig. 3. *Crassispirifer broilii* Waterhouse, 2004; specimen from Ayer Mati near Kupang, probably late Wuchiapingian (THD 2650, collection Mollengraaff). A, ventral view, x 0.9. B, anterior view, x 0.9. C, dorsal view, x 0.9.

Type locality and horizon. Basleo (Timor, Indonesia), probably early Wuchiapingian.

Material. The holotype; a specimen from Ayer Mati near Kupang probably of late Wuchiapingian age (THD 2650, collection Moolengraaff; see Fig. 3A-C), here tentatively assigned to this species; and possibly another specimen from Basleo (Broili 1916: pl. 121, fig. 1; see Waterhouse, 2004: 156).

Diagnosis. Medium-sized, transverse shell with comparatively narrow sulcus widening anteriorly, fold low; plicae well defined with one pair in sulcus; deltidial plate was present but is lost.

Description. Medium-sized, transverse shell, probably with hinge somewhat less than the greatest width (although no complete specimens are known). Umbo low, comparatively narrow sulcus widening anteriorly, fold low; plicae well defined with one pair in sulcus anteriorly, costae forming distinct fasciculae. Pedicle valve interior shows that a deltidial plate was present but is lost, no callosity developed (according to Waterhouse, 2004; cannot be seen on the only published figure: Broili 1916: pl. 120, fig. 11); adminicula are present. Brachial valve interior (also according to Waterhouse, 2004) with well developed ctenophoridium, a slender medium septum in front of it, and small crural plates.

Comments. The species is based on a fragmentary internal mould of which only the ventral side has been figured by Broili (1916: pl. 120, fig. 11). Unfortunately the specimen has not been refigured by Waterhouse (2004). The original description of the species was partly based on specimens which are considered not to be conspecific by the present author and are described below as *Latispirifer archboldorum* sp. nov. The micro-ornamentation could not be observed on the holotype. The species is distinguished from *C. timorensis* (Martin, 1881) mainly by its less convex brachial valve, wider and less sharp sulcus, and the absence of a prominent central costa in the sulcus.

The specimen from Leti described and figured by Broili (1915: pl. 21, fig. 19) and questionably assigned to *Crassispirifer broilii* by Waterhouse (2004: 155) shows no close similarity to this species, nor to *Latispirifer archboldorum*.

Genus **Latispirifer** Archbold & Thomas, 1985

Type species. *Latispirifer callytharrensensis* Archbold & Thomas, 1985.

Diagnosis. Shell large, transverse; ornament consisting of numerous fine equidimensional costae, which may bifurcate and trifurcate, plicae and fasciculation weak to moderately developed; prominent growth-lines, capillae absent; fold (fastigium) and sulcus prominent. Delthyrial plates variably developed.

Discussion. The genus *Latispirifer*, as emended here, is regarded to belong to the Fuispiriferinae rather than to the Spiriferinae (see Waterhouse, 2004: 145) because its fasciculation, though sometimes weakly developed, and transverse shape indicate a closer relation to that group. It is distinguished by its wide shell and differs from *Fuispirifer* (Waterhouse, 1966) and *Transversaria* (Waterhouse & Gupta, 1983) by its high fold and deep sulcus (see Archbold & Thomas, 1985).

Distribution. Permian of Australasia: Western Australia, Timor (Indonesia), and possibly the Urals.

Latispirifer archboldorum sp. nov.

Figs 4A-D, 5, 6A-C, 7A-B.

pars Spirifer fasciger Keyserling – Broili, 1916: 37, pl. 121, figs. 2, 3 (non cet.).

pars Spirifer fasciger Keyserling – Hamlet, 1928: 38.

Holotype. THD 12476, damaged bivalved specimen figured by Broili (1916: pl. 121, fig. 2; Figs 3A-E).

Type locality and horizon. Noil Fatoe near Niki-Niki (Basleo area, Timor, Indonesia), probably early Wuchiapingian.

Derivatio nominis. The species is dedicated to the late Professor Neil Archbold and his wife Linda for their kind hospitality during my visit to Melbourne (Deakin University) for the project ‘Permian brachiopods of Timor’.

Material. The holotype and specimens THD 12478 (Broili, 1916, pl. 121, fig. 3; refigured as Fig. 5), THD 12474’ and L8519a & L8519b (from near Basleo, probably early Wuchiapingian; collection Artis Geologisch Museum, Amsterdam).

Diagnosis. Large species of *Latispirifer* with well developed plicae and thin costae forming fasciculae.

Description. Large shells (specimen THD 12478 is as far as I know the largest spiriferid that ever lived).

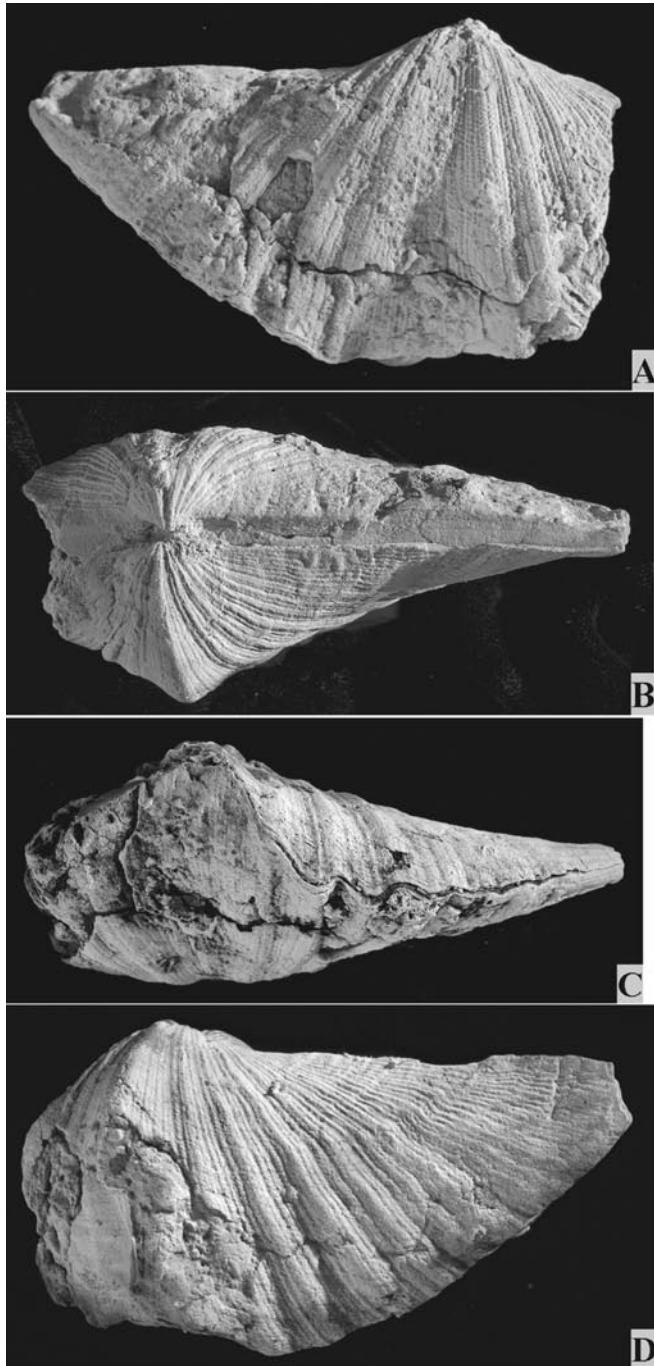


Fig. 4. *Latispirifer archboldorum* sp. nov.; holotype THD 12476, collection Molengraaff, noil Fatoe near Niki-Niki (Basleo area, Timor, Indonesia), probably early Wuchiapingian (see also Broili, 1916, pl. 121, fig. 2). A, ventral view, x 0.8. B, posterior view, x 0.8. C, anterior view, x 0.8. D, dorsal view, x 0.8.

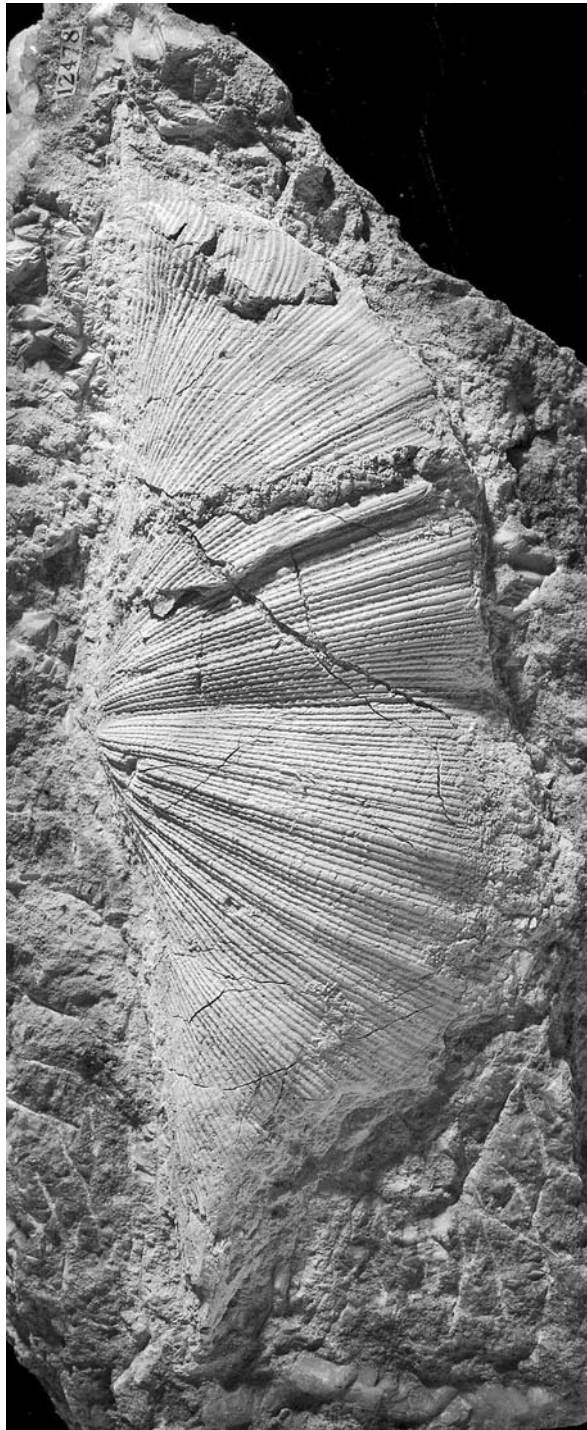


Fig. 5. *Latispirifer archboldorum* sp. nov.; large pedicle valve (THD 12478, collection Molengraaff), Sabau NNW of Kupang, probably late Wuchiapingian in age (see also Broili, 1916, pl. 121, fig. 3), x 1.

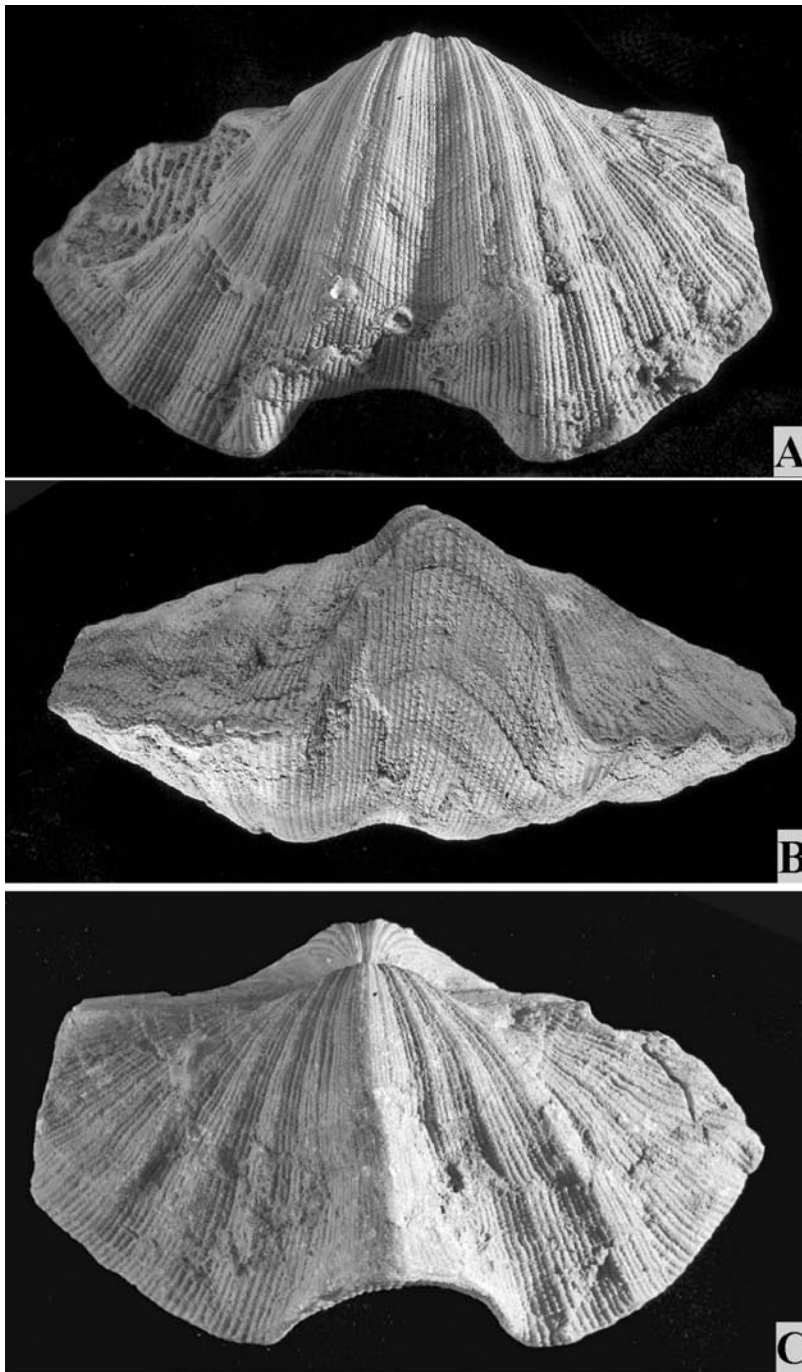


Fig. 6. *Latispirifer archboldorum* sp. nov. A-C, Specimen THD 12474' labelled: 'THD 12474 *Spirifer fasciger* Keyserling, Bitauai, Broili, 1916, pl. 120, fig. 13', but not identical with the specimen figured by Broili, collection Molengraaff, Bitauai?'. A, ventral view, x 1. B, anterior view, x 1. C, dorsal view, x 1. If the specimen is indeed from Bitauai, it is probably of Kungurian-Ufimian age.

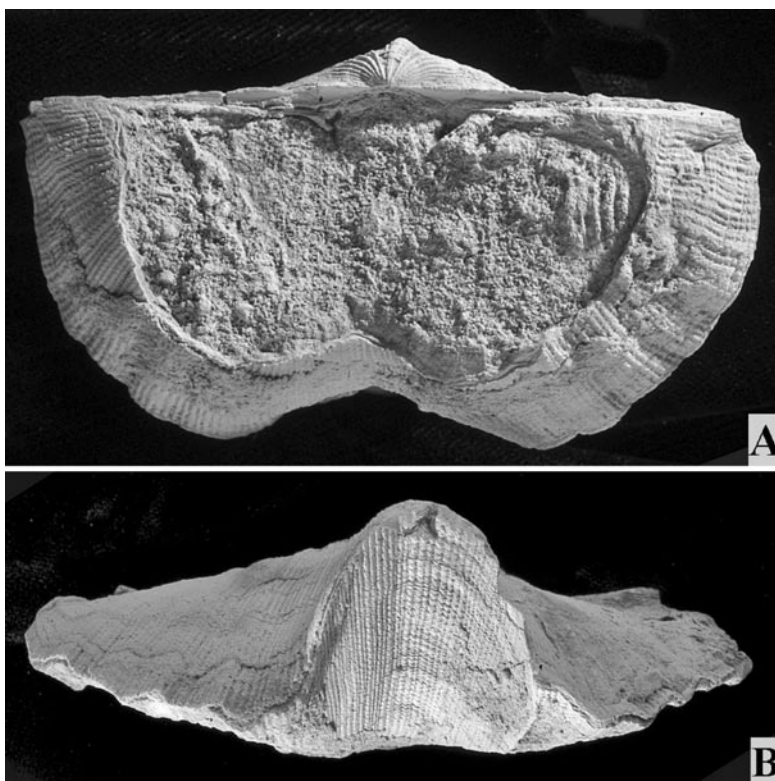


Fig. 7. *Latispirifer archboldorum* sp. nov. A-B, specimen from near Basleo, probably early Wuchiapingian in age (collection Artis Geologisch Museum L8519a). A, ventral view, most of pedicle valve missing, showing adminicula, part of spiralia and the interarea of the brachial valve, x 1. B, anterior view, x 1.

Plicae and fasciculation well developed, more than normal for the genus, becoming less distinct laterally and anteriorly, but still observable at the anterior margin. Costae thin, equidimensional. Hinge widest part of the shell, ears small. Delthyrial plates not observed. Internal structure unknown.

Comparison. From the species assigned to *Latispirifer* by Archbold & Thomas (1985) our species is distinguished by its large size, more prominent fasciculation and the absence of delthyrial plates.

Crassispirifer timorensis (Martin, 1881), on the other hand, has an even more prominent fasciculation, coarser costae with a prominent central costa in the sulcus and is less wide, being almost as long as wide, and has a more globose shape. *Crassispirifer broilii* Waterhouse, 2004 is smaller, more quadrate and has coarser costae.

Family SPIRIFERELLIDAE Waterhouse, 1968

Genus **Archboldiella** gen. nov.

Type species. *Spirifer basleoensis* Hayasaka & Hosono, 1951.

Diagnosis. The genus is distinguished by its peculiar ornamentation of parallel costae in the sulcus and on the fold.

Discussion. Although apart from the holotype of the type species (Hayasaka & Hosono 1951, Fig. 1) only one other (deformed) specimen was assigned to the type species (Broili 1916, pl. 120, fig. 15), the parallel costae in the sulcus are considered so characteristic, that the creation of a new genus seems warranted. The remainder of the ornamentation and the shape of the shell suggest that this genus belongs to the Spiriferellidae and is closest to *Arcullina* Waterhouse, 1986, since it also lacks a median groove on the fold.

A third specimen was found in the Molengraaff collection of our museum (formerly in Delft), supporting the idea that the type species is not just an aberrant form. Unfortunately, it was borrowed by Neil Archbold for closer study and should at the moment still be at Deakin University.

Distribution. *Archboldiella* is only known from the Permian (probably early Wuchiapingian) of Basleo (Timor, Indonesia).

ACKNOWLEDGEMENTS

The author wishes to thank the reviewers (Professor Shuzhong Shen and an anonymous one) and Professor Guang Shi for their constructive comments which helped to improve the manuscript.

Thanks are also due to Mesrs A. van Haasteren (Leiden University) and E.J. Bosch for taking most of the photographs. The photograph showing the micro-ornamentation (Fig. 1E) was made with the help of my colleague Dr W. Renema.

The identification of the borings on *Crassispirifer* cf. *timorensis* (Martin, 1881) (THD 12473, Fig. 1F) as *Oichnus simplex* Bromley, 1981 by my colleague Dr S.K. Donovan is gratefully acknowledged.

REFERENCES

- ABRAMOV, B.S. & GRIGORIEVA, A.D., 1986. *Biostratigraphy of Early Carboniferous brachiopods from Verchoyan*. Izdatel. Nauk, Moscow: 150 pp. [in Russian]
- ABRAMOV, B.S. & GRIGORIEVA, A.D., 1987. *Doescherella* – new generic name of Spiriferid (Brachiopoda). *Paleontologicheskij Zhurnal*, 1987 (2): 121 [in Russian; English translation: *Doescherella* – new generic name of Spiriferid (Brachiopoda). *Paleontological Journal*]
- ARCHBOLD, N.W. & BIRD, P.R., 1989. Permian Brachiopoda from naar Kasliu Village, West Timor. *Alcheringa*, 13: 103–123.
- ARCHBOLD, N.W. & THOMAS, G.A., 1985. New genera of Western Australian Permian Spiriferidae (Brachiopoda). *Alcheringa*, 9: 269–292.
- ARCHBOLD, N.W. & THOMAS, G.A., 1986. *Neospirifer* and *Trigonotreta* (Spiriferida, Brachiopoda) from the Permian of Western Australia. *Alcheringa*, 10: 125–161.
- BEYRICH, E., 1865. Über eine Kohlenkalk-Fauna von Timor. *Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin, physikalische Klasse*, 1864: 61–98, pls 1–3.
- BROILI, F., 1915. Permische Brachiopoden der Insel Letti. *Jaarboek van het Mijnwezen in Nederlandsch Oost-Indië*, 43: 187–207.
- BROILI, F., 1916. Die Permische Brachiopoden von Timor. *Paläontologie von Timor*, 7 (12): 1–104.
- BROMLEY, R.G., 1981. Concepts in ichnotaxonomy illustrated by small round holes in shells. *Acta Geologica Hispanica*, 16: 55–64.
- CARTER, J.L., 2006. Spiriferoidea. In: Williams, A. et al. *Treatise on Invertebrate Paleontology. Part H. Brachiopoda Revised, volume 5: Rhynchonelliformea (part)*, R.L. Kaesler, ed. The Geological Society of America Inc. & The University of Kansas, Boulder CO & Lawrence KA: 1769–1811.
- CHARLTON, T., BARBER, A., HARRIS, R., BARKHAM, S., BIRD, P., ARCHBOLD, N.W., MORRIS, N., NICOLL, R., OWEN, H., SORAUF, J., TAYLOR, P., WEBSTER, G. & WHITTAKER, J., 2002. The Permian of Timor: stratigraphy, palaeontology and palaeogeography. *Journal of Asian Earth Sciences*, 20: 719–774.
- HAMLET, B., 1928. Permische Brachiopoden, Lamellibranchiaten und Gastropoden von Timor. *Jaarboek van het Mijnwezen in Nederlandsch-Indië*, 56 (2) [for 1927]: 1–115, 12 pls.
- HAYASAKA, I. & HOSONO, M., 1951. A new Permian *Spirifer* from Timor. *Short Papers of the Institute of Geology and Paleontology, Sendai*, 3: 25–28.
- HOSKING, L.V.F., 1931. Fossils from the Wooramel District, Western Australia. *Journal of the Royal Society of Western Australia*, 17: 7–52.
- KING, W., 1846. Remarks on certain genera belonging to the class Palliobranchiata. *Annals and Magazine of Natural History*, 1, 18: 26–42, 83–94.
- MARTIN, K., 1881. Die versteinungs-fuehrenden Sedimente Timors nach Sammlungen von Reinwardt, Macklot und Schneider. *Sammlungen des Geologischen Reichs-Museums in Leiden*, Serie 1 (Beiträge zur Geologie

- Ost-Asiens und Australiens, 1: 1–64, pls 1–3.
- MARTIN, K., 1892. Die versteinierungs-fuehrenden Sedimente Timors nach Sammlungen von Reinwardt, Macklot und Schneider. *Jaarboek van het Mijnwezen in Nederlandsch Oost-Indië*; 11 also 1882, Wetenschappelijk Gedeelte, Palaeontologie van Nederlandsch-Indië, Verhandeling 12: 71–135, pls 1–3. (Identical to Martin, 1881.)
- MUIR-WOOD, H.M. & COOPER, G.A., 1960. Morphology, classification and life habits of the Productoidea (Brachiopoda). *Geological Society of America Memoir*, 81: 447 pp., 135 pls.
- PANNEKOEK, A.J., 1931. Brachiopoda. *Leidsche Geologische Mededeelingen*, 5 (Feestbundel K. Martin): 396–435. [in German]
- WAAGEN, W., 1883. Productus Limestone Fossils, Brachiopoda. *Palaeontologica Indica*, 13 (Salt Range Fossils), vol. 1, part 4 (2): 391–546.
- WATERHOUSE, J.B., 1966. Lower Carboniferous and Upper Permian brachiopods from Nepal. *Jahrbuch der Geologischen Bundes-Anstalt*, 12: 5–99.
- WATERHOUSE, J.B., 1968. The classification and descriptions of Permian Spiriferida (Brachiopoda) from New Zealand. *Palaeontographica*, A, 129: 1–94.
- WATERHOUSE, J.B., 1986. New late Palaeozoic invertebrate taxa. *Bulletin of the Indian Geological Association*, 19: 1–8.
- WATERHOUSE, J.B., 2004. Permian and Triassic stratigraphy and fossils of the Himalaya in northern Nepal. *Earthwise*, 6: 285 pp.
- WATERHOUSE, J.B. & GUPTA, V.J., 1983. A faunule from the *Lamnimargus himalayensis* Zone in the upper Shyok Valley, southern Karakorum Range. *Contributions to Himalayan Geology*, 2: 234–245.
- WILLIAMS, A., CARLSON, S.J., BRUNTON, C.H.C., HOLMER, L.E. & POPOV, L.E., 1996. A supra-ordinal classification of the Brachiopoda. *Philosophical Transactions of the Royal Society of London*, B, 351: 1171–1193.
- WINKLER PRINS, C.F., 1989. Brachiopoden. *Gea*, 22 (4): B9–16. [in Dutch]
- WINKLER PRINS, C.F., 2004. The geological collections of the Nationaal Natuurhistorisch Museum (Leiden, The Netherlands): cultural heritage of the geosciences and mining. In: Proceedings of VII International Symposium ‘Cultural Heritage in Geosciences, Mining and Metallurgy: Libraries – Archives – Museums’ ‘Museums and their collections’, Leiden, 2003, Winkler Prins, C.F. & Donovan, S.K., eds., *Scripta Geologica Special Issue*, 4: 293–307.