

LATE ORDOVICIAN BRACHIOPODS FROM TAIMYR, ARCTIC RUSSIA, AND THEIR PALAEOGEOGRAPHICAL SIGNIFICANCE

by L. R. M. COCKS and T. L. MODZALEVSKAYA

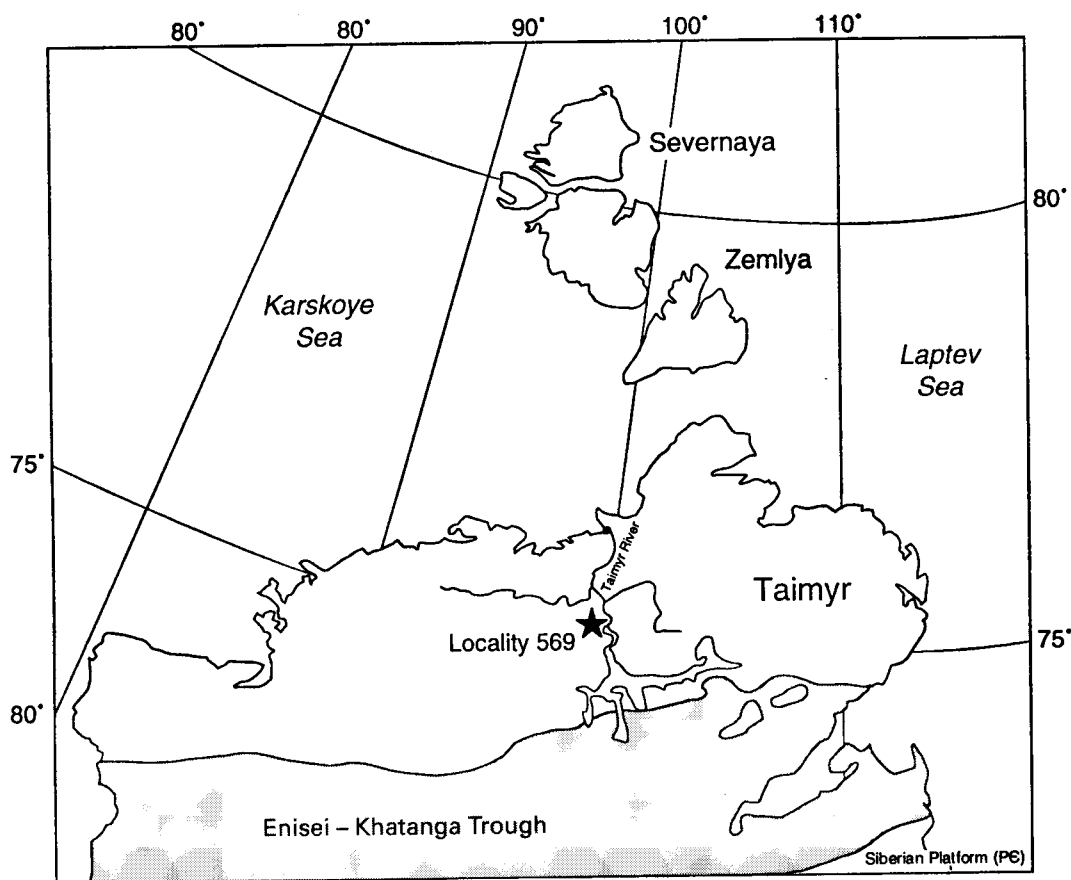
ABSTRACT. Diverse brachiopod faunas are recorded and partly described from the Korotkinskaya Formation of the central Taimyr Peninsula, northern Siberia, Russia. The lowest fauna (Beds 2 and 3) includes eight species of indeterminate late Ordovician age, the main fauna (Bed 4) consists of 39 species of mid Ashgill age, and the highest fauna (Beds 8 and 9), four species of late mid Ashgill age. The new species *Amphiplecia bondarevi*, *Cyclospira orbus*, *Eospirigerina vetusta* and *Plectatrypa laticostata* are described. Close links are drawn with the brachiopod fauna of the Boda Limestone (middle Ashgill) of Dalarna, Sweden, including the identification from Taimyr of forms hitherto considered typical of Dalarna. There are no comparable faunas from rocks of the same age on the now adjacent Siberian Platform. These data strengthen the case for the Taimyr Peninsula forming part of the palaeocontinent of Baltica during the late Ordovician.

THE Taimyr Peninsula, in northern Siberia, has been identified for some years as containing late Ordovician and early Silurian rocks and fossils (e.g. Bondarev *et al.* 1968). However, the brachiopod faunas which occur at various places and horizons are not well known. In particular, although a few parts of a key collection made from rocks of Ashgill age by V. I. Bondarev in 1959 have been described previously (Nikiforova 1982, 1985, 1989; Nikiforova *et al.* 1982), the assemblage as a whole has not, and we feel that it is important enough to be reviewed as a complete fauna in this paper, and its biogeographical position evaluated against other contemporary late Ordovician faunas.

LOCALITY AND AGE

The material comes from the Lower Taimyr River Basin (Text-fig. 1) in central Taimyr, from a continuous section along the left bank of the Pryamaya River, about 10 km south of its mouth (localities 542 and 569) at longitude 99° 54' E and latitude 75° 15' N, and from Locality 1141 on the right bank of the same river 3 km away, at the same stratigraphical level and on the opposing flank of an anticline. The brachiopods occur chiefly at three levels within the Korotkinskaya Formation (Text-fig. 2): the lower one from the 38 m thick Bed 3, the middle one from the 22 m thick Bed 4, and forming the bulk of the material mentioned in this paper, and the higher one in the 30 m thick Bed 9.

The age of the whole Korotkinskaya Formation is probably Ashgill, although this dating is more secure in its upper half. Bed 9, containing the pentamerids *Tcherskidium* and *Holorhynchus*, is clearly of mid Ashgill age. The only graptolites recovered from the locality were *Climacograptus sensu stricto* sp., determined by Dr R. F. Sobolevskaya, who also considers that Bed 4a, in which they occur, therefore represents the *supernus* Biozone and certainly antedates the highest Ordovician *persculptus* Biozone. The brachiopods described here and bryozoans determined by Nekhorosheva (1968) from Bed 4 are also of mid Ashgill age. The age of the beds below Bed 4 is less well constrained; the *Anoptambonites* illustrated here from Bed 3 could be of latest Caradoc or early Ashgill age.



TEXT-FIG. 1. The Taimyr Peninsula, northern Siberia, showing locality 569 from which the fossils described in this paper were collected.

FAUNAL AFFINITIES OF TAIMYR IN THE LATE ORDOVICIAN

The preservation of the brachiopods in the limestones makes identification of this relatively small collection often difficult since some of the taxa are represented by only one or two valves. Nikiforova (1989) identified and illustrated the pentamerides *Holorhynchus* ex gr. *giganteus*, *Tcherskidium unicum* and *Tcherskidium?* sp. nov. from Bed 9 and *Parastrophina lindstroemi pentagonalis* from Bed 4. The fauna from Bed 4 (including localities 4, 4a, 562 and 1141) has been the subject of some disparate papers: Nikiforova (1982) recorded and illustrated the inarticulates *Ectenoglossa?* sp., her new species *Multispinula bondarevi* and in addition elkaniid gen. et sp. indet. from Bed 6b and *Paracraniops?* sp. from Bed 3b. The orthides formed the subject of a further paper by Nikiforova (1985), in which *Hesperorthis* sp., the new species *Ptychopleurella alata*, *Plectorthis* ex gr. *ponderosa*, *Skenidioides* sp., *Dalmanella* sp., the new subspecies *Howellites wesenbergensis aenigmus*, and *Dicoelosia* sp. were all described from Bed 4. In addition, the new atrypid genus and species *Euroatrypa tajmyrica* were recognized from Bed 4 by Nikiforova *et al.* (1982). We have briefly reviewed, and in part amended, these attributions in the section on systematic palaeontology below. We also deal with the remainder and majority of the collection from these localities, principally including triplesioids, strophomenides and further atrypoids. The following fauna is now known, from the various horizons (Text-fig. 2):

Bed 9. *Tcherskidium unicum*, *Holorhynchus giganteus*, indet. strophomenoid.

- Bed 8. *Eoplectodonta* sp.
 Bed 6. elkaniid gen. et sp. indet., *Eospirigerina vetusta*.
 Bed 4 (including Bed 4a and Localities 562 and 1141). *Ectenoglossa?* sp., *Multispinula bondarevi*, *Paracraniops* sp., acrotretid gen. et sp. indet., *Hesperorthis?* sp., *Plectorthis* sp., *Ptychopleurella alata*, *Skenidioides* sp., gen. nov. aff. *Cyrtonotella*, *Dalmanella* sp., *Howellites aenigmus*, *Laticrura?* sp., *Dicoelosia* sp., *Epitomyonia* sp., *Ogmoplecia* aff. *plicata*, *Amphiplecia bondarevi*, *Triplesia* sp., *Leangella* sp., *Sowerbyella* (*Sowerbyella*)? sp., *Sowerbyella* (*Rugosowerbyella*) sp., *Eoplectodonta* aff. *rhombica*, *Eoplectodonta* sp., *Drummuckina?* sp., *Geniculina* sp., *Holtedahlina* sp., indet. strophomenoid, leptaeine spp., *Fardenia?* sp., *Parastrophina pentagonalis*, *Parastrophinella?* sp., *Tcherskidium* sp., *Holorhynchus* aff. *giganteus*, *Catazyga* sp., *Cyclospira orbis*, *Plectatrypa?* *laticostata*, *Qilianotryma tajmyrica*, *Eospirigerina vetusta*, indet. cyrtiinid.
 Bed 3 (including Bed 3b). *Paracraniops* sp., *Plectorthis* sp., *Dalmanella* sp., *Sowerbyella* (*Rugosowerbyella*) sp., *Eoplectodonta* sp., *Anoptambonites* sp., *Geniculina* sp.
 Bed 2 (including Bed 2a). *Sowerbyella* (*Rugosowerbyella*) sp., *Christiania* sp.

Although the fauna of Bed 9 (*Tcherskidium* and *Holorhynchus*) is of use in determining an accurate mid Ashgill (late Rawtheyan) age, these large pentamerides are now known to occur in many places in the late Ordovician tropical areas (apart from *Tcherskidium* in Laurentia). The chief interest of the Taimyr fauna lies in the 39 different species identified from Bed 4, a most diverse fauna, and also distinctive in the rather surprising complete absence of rhynchonellides. The assemblage is dominated by atrypides, with more than 60 specimens of *Qilianotryma tajmyrica*, 37 of *Plectatrypa?* *laticostata* and 43 of *Eospirigerina vetusta*, totalling 140 of the 304 brachiopod specimens known from that level. The assemblage most similar to that from Taimyr is that from the Boda Limestone of Dalarna, Sweden. Unfortunately, that fauna has never been completely assessed and described; in addition, there are certainly different assemblages present in the varied and complex Boda carbonate mounds and flank deposits. Nevertheless we have been able to examine the large collection from the Boda Limestone in the Riksmuseum, Stockholm, and a smaller one in The Natural History Museum, London. The presence in Taimyr of the triplesiid *Amphiplecia*, hitherto known only from Sweden and Norway (Wright and Jaanusson 1993), and *Ptychopleurella alata* and *Fardenia?* sp., which seem identical to those known only otherwise from Dalarna, indicates close faunal connections between the two areas. Other forms from Taimyr, such as *Eoplectodonta rhombica*, *Ogmoplecia* aff. *plicata*, *Geniculina* and *Parastrophina*, also reinforce the Baltic affinities of the fauna, although many other genera, such as *Dicoelosia*, *Howellites*, *Cyclospira*, *Qilianotryma* and *Eospirigerina*, are of much more cosmopolitan distribution in the upper Ordovician. Thus the Taimyr fauna is identified here as of undoubted Baltic affinity.

These faunas from Taimyr and elsewhere in Baltica are in marked contrast with the Ashgill faunas known from the main Siberian palaeocontinent (Andreeva and Nikiforova 1955; Nikiforova and Andreeva 1961; Rozman 1977; Yadrenkina 1984), and most of the rest of Asia, for example north-east Asia (Rozman *et al.* 1970), Gornoi Altai and Salair (Severgina 1978), Kazakhstan (Nikitin *et al.* 1996) and Mongolia (Rozman 1981), which have abundant rhynchonellides, and different plectambonitoid and strophomenoid genera.

PALAEOGEOGRAPHY OF TAIMYR

The Ordovician facies in the Taimyr belt are themselves divided into two distinct groups: to the north-west deeper-water deposits with graptolite shales, and to the south-east shelf deposits with predominantly dolomites, limestones and marls. The limestones in which the Bed 4 faunas are found, as well as the pentamerides including *Holorhynchus* and *Tcherskidium* of Bed 9, suggest a warm shelf environment for the south-eastern belt. However, rocks of latest Ashgill (Hirnantian) age are not yet known from Taimyr. Elsewhere, such Hirnantian rocks have yielded variable *Hirnantia* assemblages which are often indicative of cooler water. To the north of the Ordovician deposits considered here in Taimyr is the substantial Kara Massif, of Precambrian age, with a core

of Archaean metamorphic rocks, more than 2000 Ma, overlain by a Riphean complex of about 1000 Ma. Relatively unmetamorphosed Vendian and Early Palaeozoic deposits overlie this complex both to the north in Severnaya Zemlya and to the south in Taimyr. To the south of the Lower Palaeozoic belt in Taimyr there is the east-west trending Enisei-Khatanga Trough (Text-fig. 1) of Mesozoic and Tertiary age which itself abuts southwards on to the Precambrian rocks of the main Siberian plate.

There is general agreement that the Siberian plate, which stretched from the Ural Mountains in the west to the Verkhoyansk Mountains in the east and from the Arctic Ocean in the north to the Kazakhstan and North China plates in the south, was a single entity during the late Ordovician (Zonenshain *et al.* 1990) and that it was inverted north to south by comparison with the present day. However, the maps of Zonenshain *et al.* and some other authors show that the Taimyr Peninsula was not part of the same continental plate as the bulk of Siberia in the Early Palaeozoic. Thus the Kara Massif, with the adjacent Early Palaeozoic deposits described here, was apparently a separate entity from Siberia during the Ordovician, with the suture between it and the Siberian plate presumably now hidden beneath the Mesozoic and Tertiary Enisei-Khatanga Trough. Zonenshain *et al.* (1990, e.g. p. 215) show the Taimyr Peninsula, Severnaya Zemlya and adjacent rocks as a separate palaeocontinent termed Arctida, but we believe from the faunal results presented here that these areas most probably formed part of the Baltica palaeocontinent, or were at most small terranes adjacent to and in direct faunal contact with it, and were faunally distinct, and presumably separate, from Siberia. It is also uncertain whether or not the three tectonically distinct blocks of the Taimyr area today were comparably close in the Ordovician, and only two of the three have Ordovician fossils recorded from them.

Since Ordovician rocks from Taimyr older than those considered here contain substantial evaporite deposits, and the faunas described in this paper are diverse and in limestones, it seems probable that the Taimyr part of the Baltic palaeocontinent was at an equatorial palaeolatitude in the Ordovician. Comparably, Bachtadse *et al.* (1995) have placed the northern margin of Baltica near the palaeoequator in the late Ordovician. Palaeomagnetic work on the Siberian Platform (Torsvik *et al.* 1995, fig. 10) has also placed the plate squarely across the palaeoequator in the late Ordovician but with the orientation inverted by comparison with the present. Thus, both the Baltic and Siberian palaeocontinents were equatorial. However, although Taimyr and Siberia were probably joined before the end of the Palaeozoic, the different Ordovician faunas suggest that the two continents may not have occupied adjacent palaeolongitudes during the Ordovician.

SYSTEMATIC PALAEOLOGY

All the following taxa come from Locality 569 in Taimyr (including locality 542-1, which is the same as 569-4), but from various numbered beds (Text-fig. 2). The material previously described and figured by Nikiforova (1982, 1985, 1989) and Nikiforova *et al.* (1982) is all in CNIGR Museum, St Petersburg, Russia: the material from this paper is in The Natural History Museum, London (BC). Comparable material from Boda, Sweden, is deposited in the Riksmuseum, Stockholm (RMS).

Superfamily LINGULOIDEA Menke, 1828

Genus ECTENOGLOSSA Sinclair, 1945

Ectenoglossa? sp.

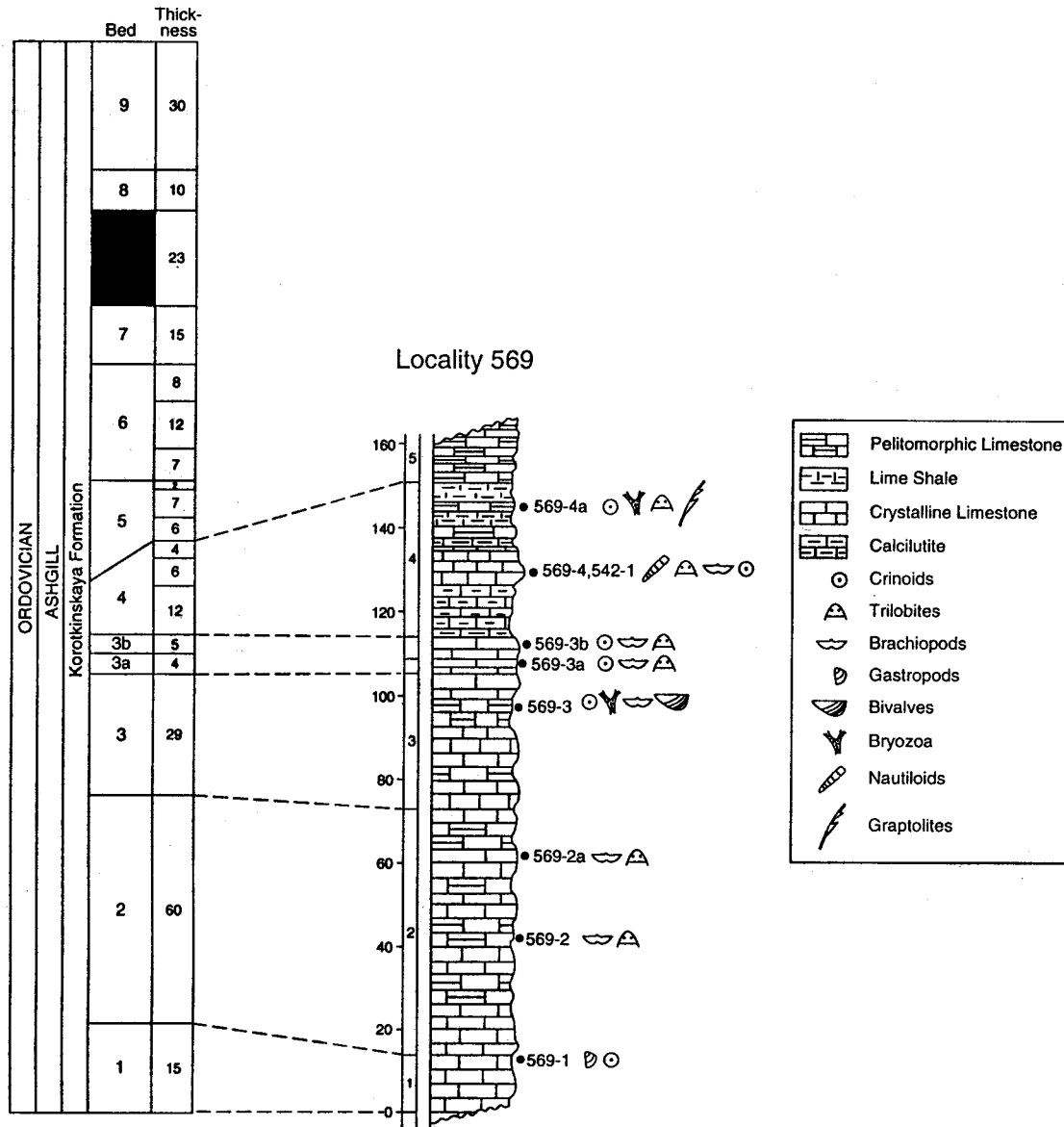
1982 *Ectenoglossa* (?) sp. Nikiforova, p. 254, pl. 1, figs 1-2.

Remarks. The two specimens described and figured by Nikiforova from Bed 4 are undoubtedly obolids but the generic attribution is uncertain. No further material has been found.

elkaniid gen. et sp. indet.

1982 Elkaniidae gen. et sp. indet. Nikiforova, p. 255, pl. 1, figs 3-5.

Remarks. Three valves were recovered from Bed 6b and Nikiforova compared one in detail with *Broeggeria*. No further material is known.



TEXT-FIG. 2. The extent and divisions of the Korotkinskaya Formation in Taimyr (left) and stratigraphical section of the rocks at Locality 569 (right), together showing the levels and beds from which the successive faunas were collected by V. I. Bondarev in 1959 and with their lithologies and faunal constituents. The black area between Beds 7 and 8 represents a gap in exposure.

Superfamily CRANIOPSOIDEA Williams, 1963

Genus PARACRANIOPS Williams, 1963

Paracraniops sp.

1982 *Paracraniops* (?) sp. Nikiforova, p. 256, pl. 1, figs 7–9.

Remarks. Nikiforova's figured specimens came from Bed 3. We have seen three further specimens (on BC 51015 and BC 51052) from Bed 4, and a further two specimens (on BC 51023) from Bed 4a. Our material compares closely with other late Ordovician *Paracraniops* material and there is no doubt as to the generic identity of the Taimyr material.

Superfamily ACROTRETOIDEA Schuchert, 1893

acrotretid gen. et sp. indet.

Remarks. Two characteristic conical valves, which may be certainly identified as acrotretids, were found in Bed 4 (on BC 51037 and BC 51052).

Superfamily SIPHONOTRETOIDEA Kutorga, 1848

Genus MULTISPINULA Rowell, 1962

Multispinula bondarevi Nikiforova, 1982

1982 *Multispinula bondarevi* Nikiforova, p. 257, pl. 1, fig. 6.

Remarks. Only the single type specimen is known, from Bed 4a.

Superfamily ORTHOIDEA Schuchert and Cooper, 1932

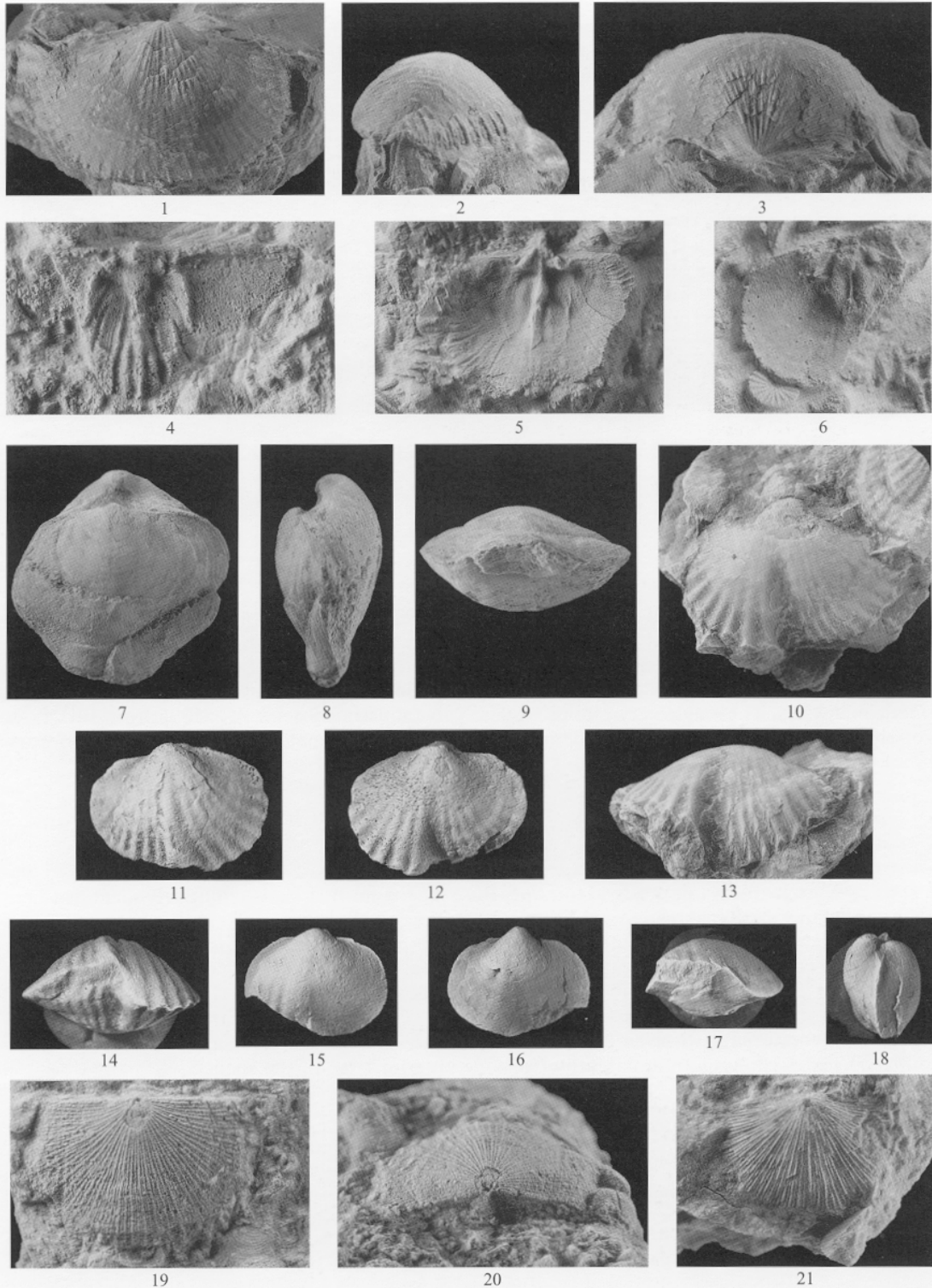
Genus HESPERORTHIS Schuchert and Cooper, 1931

Hesperorthis? sp.

1985 *Hesperorthis* sp. Nikiforova, p. 70, pl. 1, fig. 1.

EXPLANATION OF PLATE 1

- Figs 1–3. *Plectorthis* sp.; BC 51095; dorsal, lateral and posterior views of a dorsal valve; Bed 4a; $\times 2$.
 Fig. 4. gen. nov. aff. *Cyrtonotella*; BC 51067; dorsal interior; Bed 4a; $\times 4$.
 Fig. 5. *Laticrura?* sp.; BC 51066; dorsal interior, Bed 4a, $\times 3$.
 Fig. 6. *Howellites aenigmus* Nikiforova, 1985; BC 51375; incomplete dorsal interior; Bed 4; $\times 4$.
 Figs. 7–9. *Holorhynchus* aff. *giganteus* Kiær, 1902; BC 51075; dorsal, lateral and anterior views of conjoined valves; Bed 4; $\times 2$.
 Figs 10–18. *Amphiplecia bondarevi* sp. nov.; Bed 4; 10, 13, BC 51068; ventral and anterior views of a ventral valve. 11–12, 14, BC 51070; holotype, dorsal, ventral and anterior views of conjoined valves. 15–18, BC 51069; dorsal, ventral, anterior and lateral views of conjoined valves. All $\times 2$.
 Figs 19–21. *Fardenia?* sp. 19–20, BC 51081; ventral and posterior views of a ventral exterior; Bed 4. 21, BC 51377; an exfoliated ventral exterior; Bed 4a. All $\times 4$.



COCKS and MODZALEVSKAYA, late Ordovician brachiopods

Remarks. Only one external of a ventral valve is known, from Bed 4, the specimen figured by Nikiforova, and the generic attribution is uncertain. Two further dorsal valves, BC 51066 and BC 51095 from Bed 4a, are also doubtfully attributed to the genus.

Genus PTYCHOPLEURELLA Schuchert and Cooper, 1931

Ptychopleurella alata Nikiforova, 1985

1985 *Ptychopleurella alata* Nikiforova, p. 71, pl. 1, figs 2–4.

Remarks. Four ventral valves and two dorsal valves are known, from Beds 4 and 4a. Nikiforova's figures show that *P. alata* is similar in many respects to the two named species of *Ptychopleurella* from the Boda Limestone of Sweden described by Wright (1982), but differs from *P. emarginata* in its shape and less robust cardinalia and from *P. twenhofeli*, originally described from the Cautleyan Portrane Limestone of Ireland, also in its shape and in its ribbing. However, Wright also distinguished a third species from Boda, based only on two pairs of conjoined valves, which he termed *Ptychopleurella* sp., and that form shows considerable similarity to Nikiforova's figures of *P. alata*, and is probably conspecific with it.

Genus PLECTORTHIS Hall and Clarke, 1892

Plectorthis sp.

Plate 1, figures 1–3

non 1956 *Plectorthis ponderosa* Cooper, p. 451, pl. 83, figs 22–32; pl. 84, figs 24–32.

1985 *Plectorthis* ex gr. *ponderosa* Cooper; Nikiforova, p. 72, pl. 1, figs 5–6.

Remarks. Nikiforova recorded one complete shell, three dorsal valves and one ventral valve from both Bed 3 and Bed 4 in Taimyr which she compared with Cooper's species. All Cooper's (1956) figured material of *ponderosa* came from the Martinsburg Formation of Virginia, which is of late Caradoc age. However, it is doubtful whether the Taimyr form is closely related to the North American species. The single very globose dorsal valve illustrated here, BC 51095 from Bed 4a, is probably also congeneric, although whether conspecific with the material illustrated by Nikiforova (1985) is difficult to say since the shell is badly exfoliated.

gen. nov. aff. *Cyrtonotella*

Plate 1, figure 4

Remarks. A single incomplete dorsal interior, BC 51067 from Bed 4a, is tentatively identified here as a new genus perhaps related to *Cyrtonotella*. The shell is certainly impunctate (punctate dalmanelloids and pseudopunctate strophomenoids are preserved on the same block), and it is flat posteriorly becoming slightly concave anteriorly. There is no means of telling whether or not ribbing is present and if so, of what type. The specimen is in some respects similar to *Cyrtonotella kukersiana* from the lower Caradoc of Estonia (Öpik 1934, pl. 47) in the form of its cardinal process, sockets and broad myophragm. However, it differs at least generically from *Cyrtonotella* in the presence of distinctive plates running anterolaterally from the anterior edge of the sockets.

Genus SKENIDIOIDES Schuchert and Cooper, 1931

Skenidioides sp.

1985 *Skenidioides* sp. Nikiforova, p. 73, pl. 1, fig. 7.

Remarks. A single broken ventral valve was recovered from Bed 4, which was described and figured by Nikiforova. A further ventral valve has been identified by us from the same bed on BC 51012.

Both show the characteristic pyramidal shape and form of *Skenidioides*, but without dorsal valves specific identification is impossible.

Superfamily DALMANELLOIDEA Schuchert, 1913

Genus DALMANELLA Hall and Clarke, 1892

Dalmanella sp.

1985 *Dalmanella* sp. Nikiforova, p. 74, pl. 1, figs 8–11.

Remarks. One pair of conjoined valves, five ventral valves and four dorsal valves were recorded by Nikiforova from Beds 3 and 4.

Genus HOWELLITES Bancroft, 1945

Howellites aenigmus Nikiforova, 1985

Plate 1, figure 6

1985 *Howellites wesenbergensis aenigmus* Nikiforova, p. 75, pl. 1, figs 12–15.

Remarks. Two articulated specimens and several others were described by Nikiforova from Bed 4. An additional dorsal valve interior, BC 51375, is figured here from Bed 4a and two further dalmanelloid ventral valve exteriors from Bed 4 (on BC 51039 and BC 51043) and four from Bed 4a (on BC 51016, BC 51022, BC 51045 and BC 51067) are identified tentatively as belonging to the same species. Although Nikiforova identified the form as a subspecies of *H. wesenbergensis*, the excellent revision of that species by Hints (1975, p. 33, pls 6–8) showed that the Taimyr form has a much thinner dorsal myophragm and a more elevated dorsal muscle platform, enabling *aenigmus* to be considered as specifically separate from *wesenbergensis*.

Genus LATICRURA Cooper, 1956

Laticrura? sp.

Plate 1, figure 5

Remarks. A single dorsal interior, BC 51066 from Bed 4a, is referred to *Laticrura* with some caution. The cardinal process is very elongate, projecting for some way posteriorly to the hinge line. The myophragm is very thin posteriorly before thickening to a prominent globosity and then becomes thin again anteriorly before merging with the valve floor at about 60 per cent. valve length. The differentiated setal sources may reflect sharper ribs externally, as shown, for example, in *Laticrura*.

Genus DICOEOSIA King, 1850

Dicoelosia sp.

1985 *Dicoelosia* sp. Nikiforova, p. 76, pl. 1, fig. 16.

Remarks. Three ventral valves with the distinctive bilobed outline of *Dicoelosia* were recovered by Nikiforova from Bed 4. No further material has been identified by us.

Genus EPITOMYONIA Wright, 1968

Epitomyonia sp.

Remarks. A single ventral valve, only showing the exterior, BC 51038 from Bed 4, has the distinctive slightly bilobed outline and curved profile of *Epitomyonia*.

Superfamily TRIPLESIOIDEA Schuchert, 1913
 Genus OGMOPLECIA Wright and Jaanusson, 1993
Ogmoplecia aff. *plicata* (Wiman, 1907)

Plate 2, figures 1–7; Text-figure 3

aff. 1907 *Triplesia plicata* Wiman, p. 12, pl. 2, figs 13–17b.

aff. 1993 *Ogmoplecia plicata* (Wiman) Wright and Jaanusson, p. 96, figs 1A–K, 2A–N, 3.

Material. Twenty specimens, many poorly preserved, all from Bed 4 or 4a (including Locality 542-1). All are dorsal valves, except BC 51114 (Pl. 2, figs 5–7), in which both valves are conjoined.

Remarks. Wright and Jaanusson (1993) erected *Ogmoplecia* based on material from the Hulterstad Limestone of Sweden, with the type species, *O. plicata*, as the sole firmly attributed species, together with forms identified as cf. *plicata* from the Portrane Limestone (Ashgill: Cautleyan) and Kildare Limestone (Ashgill: Rawtheyan) of Ireland, the Dolhir Formation (Ashgill: Rawtheyan) of Glyn Ceiriog, North Wales, the Fosse Formation (Ashgill: Cautleyan–Rawtheyan) of Belgium, and the Ashgill Vormsi, Pirgu and Porkuni stages of Estonia. All these occur in Baltica or the neighbouring continent of Avalonia which was in faunal contact if not actually physically joined by the Ashgill (Cocks and Fortey 1990). In addition, Wright and Jaanusson provisionally attributed with a query two of the four species, *insolita* and *shallockiensis*, which were attributed to *Oxoplecia* by Harper (1989) from the upper Ordovician of the Girvan district, Scotland, which then lay on the opposite side of the closing Iapetus Ocean to Baltica and Avalonia.

The dorsal valves, which form a substantial part of the Taimyr Bed 4 and Bed 4a fauna, are very similar to the specimens of *O. plicata* illustrated by Wright and Jaanusson (1993) and the Taimyr material is identified here as *Ogmoplecia* aff. *plicata*. The Taimyr material is attributed to *Ogmoplecia* rather than its near homoeomorph *Oxoplecia* because it lacks a proximal pseudodeltidial fold and the section (Text-fig. 3) shows the absence of the keeled cardinal process, both considered key features by Wright and Jaanusson (1993).

Genus AMPHIPLECIA Wright and Jaanusson, 1993

Amphipectia bondarevi sp. nov.

Plate 1, figures 10–18

Derivation of name. After V. I. Bondarev, who collected the material.

Holotype. BC 51070, Plate 1, figures 11–12, 14; conjoined valves, Locality 569, Bed 4.

EXPLANATION OF PLATE 2

Figs 1–7. *Ogmoplecia* aff. *plicata* (Wiman, 1907). 1, 4, BC 51115, dorsal and lateral views of a dorsal valve; Bed 542-1. 2, BC 51109; dorsal exterior; Bed 4a. 3, BC 51110; anterior view of a dorsal valve; Bed 4a. 5–7, BC 51114; dorsal, anterior and lateral views of conjoined valves; Bed 542-1. All $\times 1.5$.

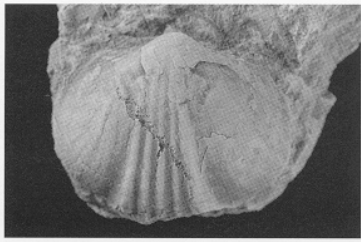
Figs 8–9. *Anoptambonites* sp.; Bed 3. 8, BC 51053; dorsal interior; $\times 2.5$. 9, BC 51054; dorsal interior; $\times 4$.

Fig. 10. leptaenine gen. et sp. indet.; BC 51376; ventral external mould; Bed 4; $\times 3$.

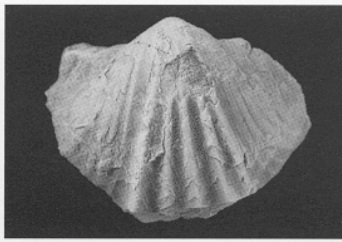
Figs 11–12. *Sowerbyella* (*Rugosowerbyella*) sp. 11, BC 51037; ventral exterior; Bed 4; $\times 3$. 12, BC 51040; partly exfoliated ventral exterior; Bed 2; $\times 4$.

Figs 13–15. *Geniculina* sp. 13, BC 51055; ventral exterior; Bed 4a. 14–15, BC 51004; dorsal and lateral views of a dorsal interior; Bed 3b. All $\times 2$.

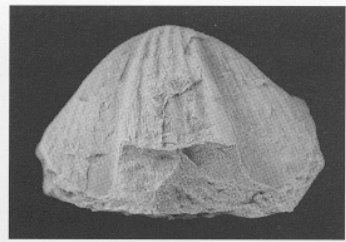
Fig. 16. *Fardenia?* sp.; BC 51052; ventral exterior; Bed 4; $\times 3$.



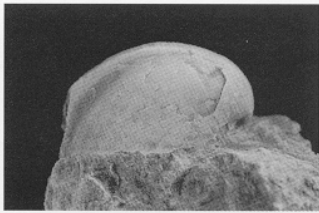
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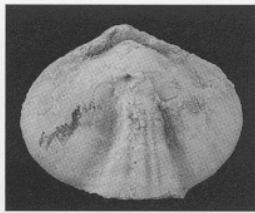
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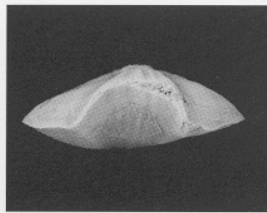
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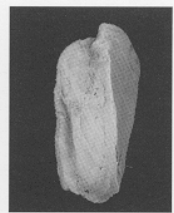
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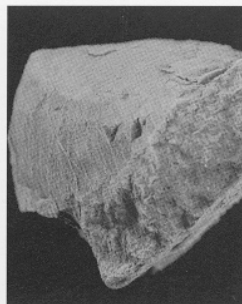
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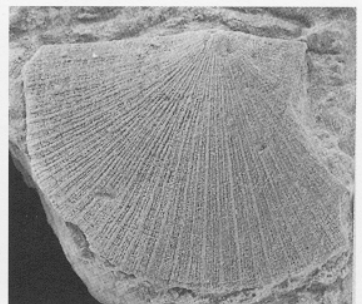
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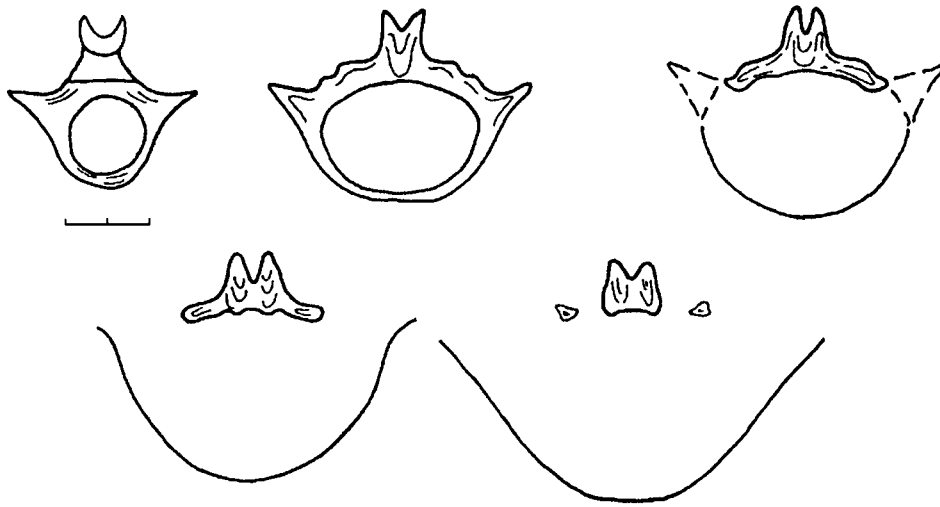
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TEXT-FIG. 3. Transverse serial sections illustrating the development of the dorsal internal structures in *Ogmoplecia* aff. *plicata* (Wiman). Scale bar represents 2 mm.

Material. Two pairs of conjoined valves, BC 51069–70, and two ventral valves, BC 51068 and BC 51616, and two dorsal valves, BC 51076 and BC 51118, all from Bed 4, and one dorsal valve, BC 51117, from Bed 4a.

Description. Sub-oval outline with width greater than length. Biconvex profile. Asymmetrical shell shape anteriorly. Ribs variably developed, absent posteriorly, between five and seven present in each valve half. Incurved beak and small interarea. Interior not known.

Dimensions. Holotype BC 51070, length 11.6 mm, width 14.2 mm, thickness 7.8 mm; paratype BC 51069, length 9.1 mm, width 11.0 mm, thickness 6.2 mm.

Remarks. The new species differs from the two species hitherto assigned (Wright and Jaanusson 1993), the type species *A. tardicostata* from the Ashgill of Boda, Sweden, and *A. depressa* from the Caradoc of Ringerike, Norway, in its more tightly incurved beak and smaller interarea. The Taimyr specimens illustrated are also smaller than those from the Baltic, but the isolated ventral valve, although not illustrated, is somewhat larger (length 14.3 mm, estimated width 20 mm). There is variation in that the ribbing is much more strongly developed in the holotype and in the isolated ventral valve than in the second articulated specimen. The genus is distinctive in its asymmetrical shell shape, the only triplesioid, apart from *Streptis*, to have one. *Amphiplecia* is known so far only from the Caradoc and Ashgill.

Genus TRIPLESIA Hall, 1859

Triplesia sp.

Plate 4, figures 1–3

Remarks. A single ventral valve, BC 51074 from Locality 1141, is a large smooth triplesioid attributable to *Triplesia*, although the preservation is relatively poor. Its width is preserved to 28 mm.

Superfamily PLECTAMBONITOIDEA Jones, 1928

Family LEPTESTIIDAE Öpik, 1933

Genus LEANGELLA Öpik, 1933

Leangella sp.

Plate 3, figures 5–7

Remarks. The distinctive lateral profile, with incurved beak and relatively large orthocline ventral interarea, and the outline with the globose umbo, form the distinctive shape identifiable as *Leangella* which is common and cosmopolitan in the Caradoc to Upper Silurian (Cocks and Rong 1989). The quinquecostate ornament is also prevalent in many species of the genus. From Taimyr, one pair of articulated valves, BC 51058 (Pl. 3, figs 5–7), and three ventral valves, BC 51059, BC 51061 and BC 51062 are known from Bed 4, and a further pair of conjoined valves, BC 51060, from Locality 1141.

Family HESPEROMENIDAE Cooper, 1956

Genus ANOPTAMBONITES Williams, 1962

Anoptambonites sp.

Plate 2, figures 8–9

Remarks. Two well-preserved dorsal valves, BC 51053–51054, and two poorer dorsal valves, BC 51794 and on BC 51793, and four poorly preserved ventral valves (BC 51793 and BC 51795) have been recovered from Bed 3 at Taimyr, at an horizon extremely rich in stick bryozoans. *Anoptambonites*, with its flaring socket ridges, strong dorsal median septum and prominent elevated and bilobed platform and muscle field is known from the upper Caradoc of Girvan, Scotland, from which Williams (1962) described the type species, but also from the Caradoc of Alaska, and Kazakhstan (Popov 1980) and the Ashgill of Ireland (Mitchell 1977). Bed 3b is less securely dated than the beds above, although it is probably of early Ashgill age.

Family SOWERBYELLIDAE Öpik, 1930

Genus EOPLECTODONTA Kozłowski, 1929

Eoplectodonta aff. *rhombica* (M'Coy, in Sedgwick and M'Coy, 1852)

Plate 3, figures 1–4, 8–10

aff. 1852 *Leptaena sericea* var. *rhombica* M'Coy, in Sedgwick and M'Coy, p. 239.aff. 1982 *Eoplectodonta rhombica* (M'Coy) Cocks, p. 769, pl. 81, figs 5–6.

Remarks. *Eoplectodonta* is a common and cosmopolitan genus from the Caradoc to the middle Silurian, with its type species from the Lower Llandovery of Wales (Cocks and Rong 1989, pp. 133–137). The only two named species from the Ashgill are *E. rhombica*, whose type specimens come from the early Ashgill Crag Hill Beds of northern England, but which has also been recorded from the middle Ashgill of the Oslo region, Norway (Cocks 1982); and *E. oscitanda* Cocks, 1982 from the mid Ashgill Langåra Formation of the Oslo region. From Taimyr, *Eoplectodonta* is a common fossil in Beds 4 and 4a, from which three pairs of conjoined valves, 19 ventral valves and three dorsal valves have been recovered, and five ventral valves from Locality 1141 have been found at a similar stratigraphical level. The largest of these is 26.5 mm wide, which, although not matching the 35 mm achieved by some specimens from Norway, is nevertheless substantially greater than the average size for the genus and has determined the provisional specific attribution. The nine specimens sufficiently well preserved to enable counting of the parvicostellae between the coarser costellae have counts of 5(1), 7(1), 9(3) and 12(4), also putting the species closer to *E. rhombica* than *E. oscitanda*. In addition,

there is a number of smaller *Eoplectodonta* specimens in Beds 4 and 4a; whether these are merely young specimens of *E. aff. rhombica* or represent a different and smaller species remains uncertain; they are listed here as *Eoplectodonta* spp.

Eoplectodonta spp.

Remarks. The two pairs of conjoined valves, BC 51020 and BC 51035, and one ventral valve, BC 51036, from Bed 3, and the two pairs of conjoined valves, BC 51027 and BC 51030, and three dorsal valves, BC 51018 and BC 51623–51624, from Bed 8 represent less incurved and smaller and different species or at least subspecies of *Eoplectodonta* from *E. rhombica* or *E. oscitanda*; however, the Taimyr material is not adequate to characterize a new taxon effectively, particularly since no interiors are available.

Genus SOWERBYELLA Jones, 1928

Subgenus SOWERBYELLA (SOWERBYELLA) Jones, 1928

Sowerbyella (*Sowerbyella*)? sp.

Remarks. One dorsal valve, BC 51015 from Bed 4, and one ventral valve, BC 51016 from Bed 4a, have a less incurved profile, different from that of *Eoplectodonta* in the same beds. Although the presence of denticles on the hingelines of these specimens cannot be determined, they are attributed provisionally to *S. (Sowerbyella)*.

Subgenus SOWERBYELLA (RUGOSOWERBYELLA) Mitchell, 1977

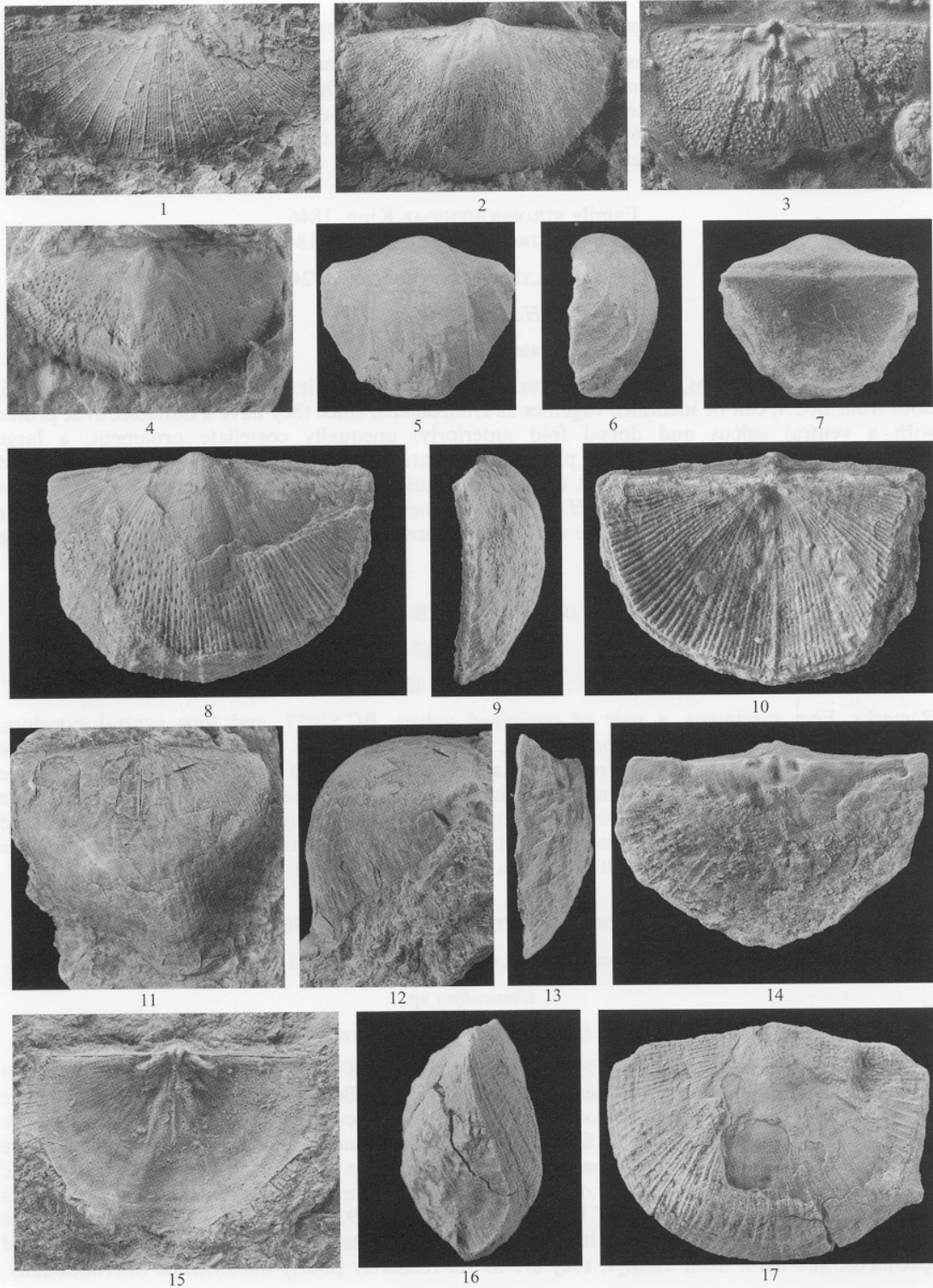
Sowerbyella (*Rugosowerbyella*) sp.

Plate 2, figures 11–12

Remarks. Several plectambonitoid exteriors (five pairs of conjoined valves, including BC 51063–51065, and five ventral valves from Bed 4, one pair of conjoined valves, BC 51014, and two ventral valves from Bed 4a, BC 51011 and BC 51023, a ventral exterior, BC 51010, from Bed 3b and BC 51040 from Bed 2) exhibit the characteristic ornament of small rugae interrupted by costellae of the subgenus *Rugosowerbyella*, whose type species (Mitchell 1977) is from the Cautleyan Killey Bridge Formation of Northern Ireland; the subgenus also occurs in the upper Caradoc and lower Ashgill of Girvan, Scotland. Plectambonitoids of uncertain generic affinity, but which display the characteristic ornament and valve profile of *Rugosowerbyella* are also recorded from the Caradoc of the Pre-Chinghiz Mountains, Kazakhstan (Klenina *et al.* 1984, p. 83, pl. 8) and from the lower Ashgill of Västergötland, Sweden (Henningsmoen 1948).

EXPLANATION OF PLATE 3

- Figs 1–4, 8–10. *Eoplectodonta* aff. *rhombica* (M'Coy, in Sedgwick and M'Coy, 1852). 1, BC 51044; ventral exterior; Bed 4a; $\times 2.5$. 2, BC 51022; ventral exterior; Bed 4a; $\times 2$. 3, BC 51043; dorsal interior; Bed 4; $\times 3$. 4, BC 51034; partially exfoliated ventral valve showing part of the interior; Bed 4a; $\times 3$. 8–10, BC 51051; ventral, lateral and dorsal views of conjoined valves; Bed 4a; $\times 5$.
 Figs 5–7. *Leangella* sp.; BC 51058; ventral, lateral and dorsal views of conjoined valves; Bed 4; $\times 5$.
 Figs 11–12. *Geniculina* sp.; BC 51007; dorsal and lateral views of a largely exfoliated dorsal valve; Bed 4; $\times 1.5$.
 Figs 13–14. *Drummuckina*? sp.; BC 51057; lateral and dorsal views of partly exfoliated conjoined valves; Bed 4a; $\times 2$.
 Figs 15–17. *Holtedahlina* sp.; Bed 4. 15, BC 51003; dorsal interior. 16–17, BC 51005; lateral and ventral views of conjoined valves. All $\times 3$.



COCKS and MODZALEVSKAYA, late Ordovician brachiopods

Superfamily STROPHOMENOIDEA King, 1846

Remarks. This superfamily has been the most difficult to identify, since in 14 specimens there appear to be at least seven different taxa, and because many of the specimens are fragmentary, these cannot all be attributed firmly to genera. Two of the specimens, a ventral valve, BC 51002 from Bed 4, and a dorsal valve, BC 51006 from Bed 9, are different from the other forms described here, but can be identified only as a indeterminate strophomenoids.

Family STROPHOMENIDAE King, 1846
 Subfamily STROPHOMENINAE King, 1846

Genus HOLTEDAHLINA Foerste, 1924

Holtedahlina sp.

Plate 3, figures 15–17

Remarks. Two specimens, a dorsal interior, BC 51003, and a pair of conjoined valves, BC 51005, both from Bed 4, can be identified together as *Holtedahlina* since they have a dorsibiconvex profile with a ventral sulcus and dorsal fold anteriorly, unequally costellate ornament, a large pseudodeltidium with small chilidial plates and an interior like the true *Strophomena* (Rong and Cocks 1994, pl. 1, figs 7, 9) but with dorsal trans-muscle ridges weakly developed. They are not conspecific with the type species, *H. sulcata* (Verneuil) from the middle Ashgill Whitewater Formation of Ohio, USA, in that the socket ridges are less elongate and the cardinal process less robust in the Taimyr specimens.

Genus DRUMMUCKINA Bancroft, 1949

Drummuckina? sp.

Plate 3, figures 13–14

Remarks. Five specimens, a pair of conjoined valves, BC 51057, and four ventral exteriors, including BC 51056–51057, all from Bed 4a, may be attributable to *Drummuckina*, whose type species *D. donax* (Reed) comes from the Ladyburn Starfish Bed (Ashgill: Rawtheyan) of the Drummuck Group, Girvan, Scotland. The Taimyr form possesses the concavo-convex profile, large chilidium, short dental plates, ventral myophragm and the trapezoidal ventral muscle field characteristic of the genus, but the ornament is unequally rather than equally costellate and the dorsal interior features are difficult to discern; hence the uncertain attribution.

Subfamily FURCITELLINAE Williams, 1965

Genus GENICULINA Rõõmusoks, 1993

Geniculina sp.

Plate 2, figures 13–15; Plate 3, figures 11–12

Remarks. Two dorsal interiors, BC 51004 from Bed 3b and BC 51007 from Bed 4, are known from Taimyr. It is possible that a ventral exterior, BC 51055 from Bed 4a, may be the same species. The dorsal valve from the lower horizon is more sharply geniculate, but both dorsal valves have substantial trails preserved (Pl. 3, fig. 12). All three specimens show unequally parvicostellate ornament, and the dorsal valves show the thin median septum and pair of side septa characteristic of *Geniculina*, although the irregular oblique wrinkles present in *G. pseudoalternata*, the type species from the mid Ashgill Pirgu Stage of Estonia (Rõõmusoks 1993), are missing. Furcitellines such as this are widespread in the Ashgill, although since they are often represented by a small number of specimens, like these from Taimyr, they are as yet relatively poorly documented internationally.

Such specimens often appear in faunal lists as *Oepikina*, although that genus, whose type species *O. septata* is from the Caradoc Lebanon Formation of Tennessee, USA, has a distinctive dorsal subperipheral rim and two or more pairs of dorsal side septa (Rong and Cocks 1994, pl. 3), in contrast with *Geniculina*, *Katastrophomena*, *Panderites*, *Trigrammaria* and other closely related genera.

Family RAFINESQUINIDAE Schuchert, 1893
Subfamily LEPTAENINAE Hall and Clarke, 1894

leptaenine spp.

Plate 2, figure 10

Remarks. Two specimens, the external mould of a ventral valve, BC 51376 from Bed 4, and a broken dorsal valve whose umbo is missing, BC 51017 from Bed 4a, belong to two different leptaenine genera. The ventral valve (Pl. 2, fig. 10) has a square outline comparable to that of *Glossoleptaena* and *Rugoleptaena*, which both occur only in the Upper Silurian and Devonian, and may represent a new genus. The geniculate dorsal valve is morphologically close to *Leptaena sensu stricto*, which ranges from the Caradoc to the Devonian. However, neither specimen can be generically determined with confidence.

Superfamily CHILIDIOPSOIDEA Boucot, 1959
Family CHILIDIOPSIDAE Boucot, 1959

Genus FARDENIA Lamont, 1935

Fardenia? sp.

Plate 1, figures 19–21; Plate 2, figure 16

Remarks. Two ventral valves, BC 51081 and BC 51052, and a possible dorsal valve on BC 51015 from Bed 4, of which only the convex exteriors are visible, probably represent a chilidiopsid. One specimen is relatively small for the group (length 6.4 mm); the other is also below medium size (length 12.2 mm). The shell, as can be seen near the umbo where the specimen is abraded, lacks pseudopunctae, but is laminar rather than fibrous. The pseudodeltidium is very prominent, making assignment to the contemporary Ashgill *Fardenia* questionable, since in that genus it is usually relatively small. The only closely related genus with a large pseudodeltidium (even larger than in the Taimyr specimen) is *Morinorhynchus*, which is only known from the Upper Silurian. A further specimen, BC 51377 from Bed 4a, also showing only the ventral exterior (Pl. 1, fig. 21) which is somewhat exfoliated, is referred provisionally to the same taxon as the form from Bed 4. There is a ventral valve, also showing only the exterior, which is virtually identical to that of the Taimyr specimens, in the Stockholm collections, RMS Br 9017, from the Boda Limestone of Arvet, Dalarna, but again, no firmly attributable interiors of either valve have yet been found from that area.

Superfamily CAMERELLOIDEA Hall and Clarke, 1894
Family PARASTROPHINIDAE Ulrich and Cooper, 1938

Genus PARASTROPHINA Schuchert and Le Vene, 1929

Parastrophina pentagonalis Nikiforova, 1989

Plate 4, figures 12–14

1989 *Parastrophina lindströmi pentagonalis* Nikiforova, p. 78, pl. 1, figs 1–4.

Remarks. Nikiforova recorded 14 specimens from Bed 4 of her new subspecies which she attributed to *P. lindstroemi* described from the Boda Limestone of Sweden (Wright 1974). A further ventral valve, BC 51077, is illustrated here from the same bed, and a small pair of conjoined valves from

Bed 4a, from which two specimens are now known. Nikiforova (1989, p. 80) suggested that the pentagonal (rather than triangular) outline, the more acute apical angle and beak, more prominent fold, and the greater number of lateral plicae are the characteristic features which led her to consider the Taimyr *Parastrophina* to be a separate subspecies of *P. lindstroemi*. However, the number of incipient costae in the fold and sulcus varies, and in some specimens they seem to be scarcely developed. Some specimens from Boda, e.g. RMS Br 6989, also tend towards a pentagonal shape, and hence a different subspecies for the Taimyr and Boda forms may not be valid. However, Nikiforova's section of the Taimyr form (1989, figure 1) does not show any alae developing from the crural plates, which is one of the characteristics of true *Parastrophina*, and until the Boda material has been worked on in more detail, her species name is retained for the Taimyr material. Nikitin *et al.* (1996) have described from Kazakhstan a new subspecies of *Parastrophina angulosa*, another species revised by Wright (1974) and also originally from the Boda Limestone. However, both in ornament and particularly also in internal section these supposed subspecies seem very different from each other and appear to warrant specific separation. Nikitin *et al.* (1996) also described a further new species, *P. tersa*, from the Kazakhstan carbonate mounds, of Ashgill age.

Genus PARASTROPHINELLA Schuchert and Cooper, 1931

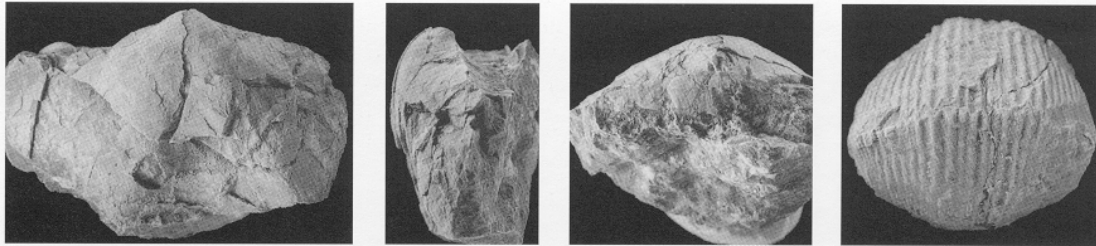
Parastrophinella? sp. A

Plate 4, figures 8–11; Text-figure 4

Five specimens from Bed 4 (BC 51078, BC 51080, BC 51090–91 and BC 51112) and three specimens from Bed 4a (BC 51092–3 and BC 51119), all *c.* 10 mm wide, can be attributed tentatively to *Parastrophinella*. All lack ornament apart from three undulose ribs in the antero-central region, commencing at about half valve length or later. A newly sectioned specimen, BC 51080, although very similar externally to the lectotype of *Parastrophina angulosa* as figured by Wright (1974, fig. 3), possesses one ventral rib and has a distinctive interior (Text-fig. 5). The ventral interior is the same as that of *Parastrophina*, with a short median septum, spondylium and teeth, but the dorsal interior has features intermediate between those of *Parastrophina* and *Parastrophinella* from the Anderken Horizon (middle to upper Caradoc) of Kazakhstan, which has a similar septalium, although the exterior has a narrower fold and sulcus and more ribs. However, the Taimyr form is attributed to *Parastrophinella* because the section (Text-fig. 4) reveals that there is a pair of divergent outer plates extending directly to the floor of the valve instead of uniting on to a median septum as in *Parastrophina*. From *Parastrophina orloviensis* from the Orlov Horizon (Ashgill) of the north-western Altai region (Severgina 1978, p. 28, pl. 3, fig. 14) it differs in possessing a narrower

EXPLANATION OF PLATE 4

- Figs 1–3. *Triplesia* sp.; BC 51074; ventral, lateral and posterior views of a ventral valve; Locality 1141; $\times 1.5$.
 Figs 4–7. *Tcherskidium* sp.; Bed 4. 4, 7, BC 51072; anterior and posterior views of conjoined valves, the latter sectioned to reveal spondylium; $\times 1.5$ and $\times 3$. 5–6, BC 51071; lateral and ventral views of a ventral valve; $\times 2$.
 Figs 8–11. *Parastrophinella?* sp. A. 8–9, BC 51092; dorsal and anterior views of a dorsal valve; Bed 4a. 10, BC 51091; ventral exterior; Bed 4. 11, BC 51093; dorsal exterior; Bed 4a. All $\times 1.5$.
 Figs 12–14. *Parastrophina pentagonalis* Nikiforova, 1989. 12, BC 51089; ventral view of conjoined valves; Bed 4a; $\times 3$. 13–14, BC 51077; ventral and anterior views of a ventral valve; Bed 4; $\times 1.5$.
 Figs 15–16. indeterminate cyrtiid; BC 51113; lateral and ventral views of a ventral valve; Bed 4; $\times 1.5$.
 Figs 17–20. *Catazyga* sp.; BC 51101; ventral, dorsal, anterior and lateral views of conjoined valves; Bed 4; $\times 2$.

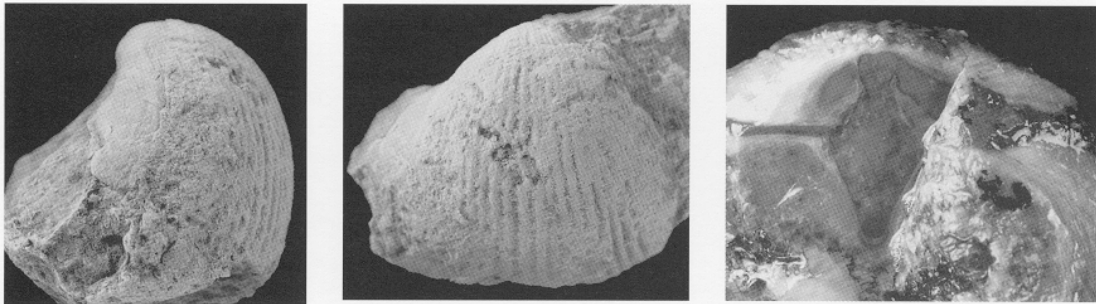


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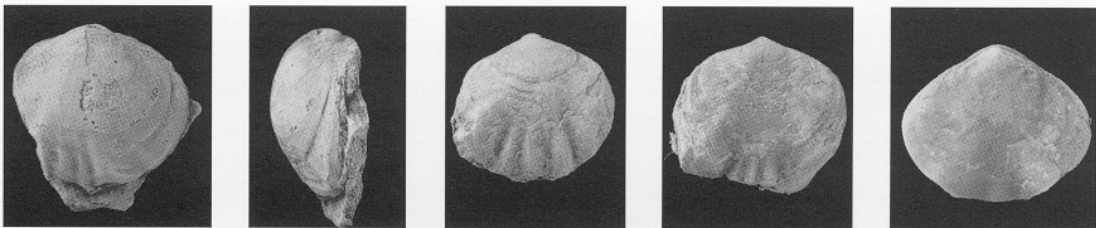
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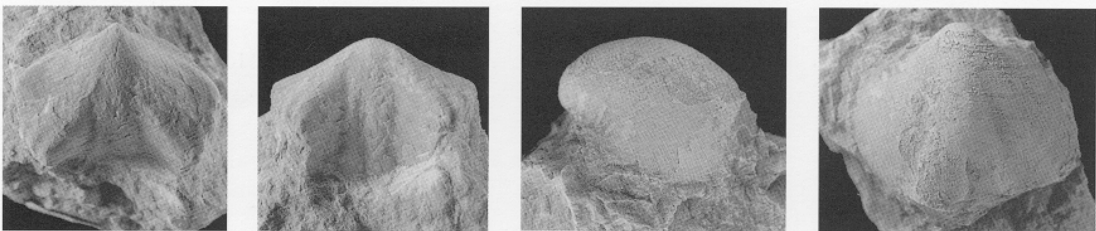
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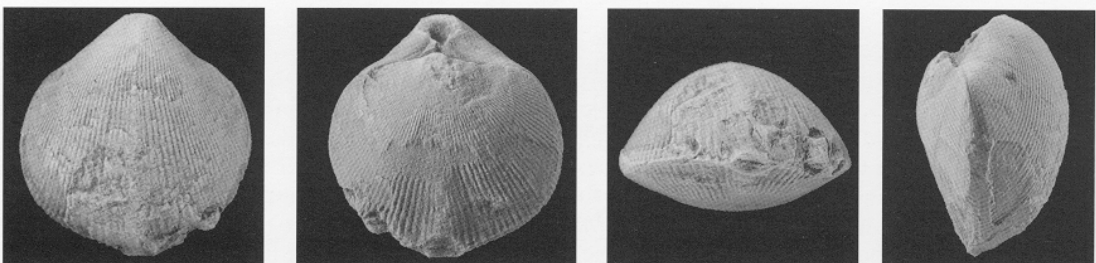


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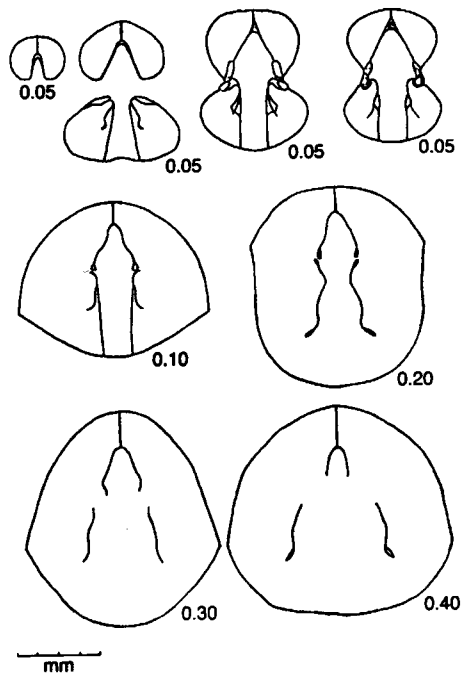
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COCKS and MODZALEVSKAYA, late Ordovician brachiopods



TEXT-FIG. 4. Transverse serial sections illustrating the development of internal structures in *Parastrophinella?* sp., BC 51080, from Locality 569, Bed 4. Distances given are those between successive sections. Scale bar represents 4 mm.

ventral sulcus and a flatter ventral valve. The Taimyr form also differs from *Parastrophinella portentosa* from Kazakhstan (Nikitin *et al.* 1996) in its ribs being confined to the valve centre and also being consistent in possessing them (the Kazakhstan specimens vary from having ribs round nearly all the anterior commissure to lacking them entirely).

Superfamily PENTAMEROIDEA M'Coy, 1844
Family VIRGIANIDAE Boucot and Amsden, 1963

Genus HOLORHYNCHUS Kiær, 1902

Holorhynchus giganteus Kiær, 1902

1902 *Holorhynchus giganteus* Kiær, p. 68, figs 1–7.

1982 *Holorhynchus giganteus* Kiær; Cocks, p. 774, pl. 83, figs 12–17.

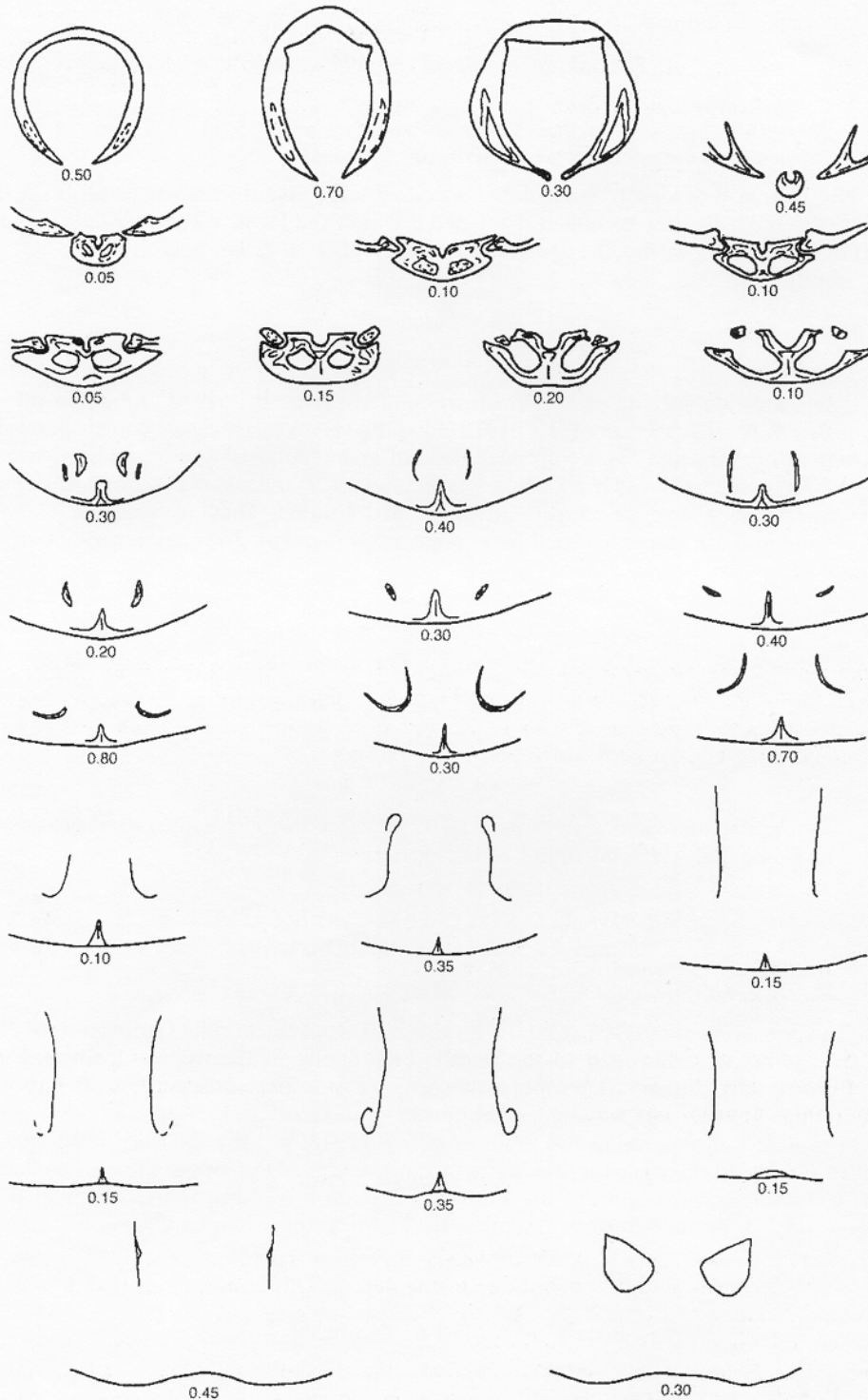
1989 *Holorhynchus* ex gr. *giganteus* Kiær; Nikiforova, p. 80, pl. 2, figs 1–3.

Remarks. Nikiforova recorded seven ventral valves and one dorsal valve, all from Bed 9, which, although only identified by her as 'ex gr. *giganteus*', we consider conspecific with Kiær's species from the middle Ashgill of Norway.

Holorhynchus aff. *giganteus* Kiær, 1902

Plate 1, figures 7–9

Remarks. In addition to the record of *Holorhynchus giganteus* from Bed 9, we figure a so far unique specimen, BC 51075, as probably attributable to the genus. This comes from Bed 4, which makes this specimen substantially older in the Ashgill than the specimens recorded by Nikiforova and probably older also than the Norwegian types. The specimen is a well-preserved pair of conjoined valves, and, although it is relatively small for the genus (length 18.2 mm), the external features compare well with juvenile specimens of *Holorhynchus giganteus* from the Oslo District (Cocks 1982). However, since no interiors are visible, we identify the specimen here as *H.* aff. *giganteus*.



TEXT-FIG. 5. Selected transverse serial sections illustrating the development of internal structures in *Cyclospira orbis* sp. nov.; BC 51125, length, 11.5 mm; width, 10.7 mm; thickness, 8 mm. Figures are distances in mm between individual sections.

Genus TCHERSKIDIUM Nikolaev and Sapelnikov, 1969

Tcherskidium unicum (Nikolaev, 1968)1968 *Conchidium unicum* Nikolaev, p. 47, pl. 2, figs 1-3.1969 *Tcherskidium unicum* (Nikolaev) Nikolaev and Sapelnikov, p. 11, pl. 1, figs 1-4.1989 *Tcherskidium unicum* (Nikolaev); Nikiforova, p. 81, pl. 2, figs 4-12.

Remarks. Nikiforova recorded 63 articulated specimens and five dorsal valves all from Bed 9. In addition, she figured a further specimen from Bed 9 which she termed *Tcherskidium?* sp. nov. and which we consider to be within the specific variability of *T. unicum*, and thus it is not included separately in our list.

Tcherskidium sp.

Plate 4, figures 4-7

Remarks. There are two specimens, a pair of articulated valves BC 51072 and a ventral valve BC 51071, from Bed 4. A cross section of BC 51072 (Pl. 4, fig. 7) reveals a clear ventral spondylium and there is a pair of dorsal septa. There are well-defined and regular costae of medium size over the whole exterior. In contrast to the higher Bed 9 fauna, where *T. unicum* is a major component, these two specimens represent a minor constituent of the Bed 4 fauna. They are somewhat smaller than typical *T. unicum* and are thus identified here as *Tcherskidium* sp., and may represent an ancestral form of the type species.

Superfamily ANAZYGOIDEA Davidson, 1882

Family ANAZYGIDAE Davidson, 1882

Genus CATAZYGA Hall and Clarke, 1893

Catazyga sp.

Plate 4, figures 17-20

Remarks. A single articulated specimen, BC 51101, with the distinctive fine radial ornament, shape and outline of *Catazyga*, has been found in Bed 4.

Superfamily LISSATRYPOIDEA Twenhofel, 1914

Family CYCLOSPIRIDAE Schuchert, 1913

Genus CYCLOSPIRA Hall and Clarke, 1893

Remarks. The type species of *Cyclospira*, *C. bisulcata*, is from the middle Ordovician of New York State and the genus is widespread in the middle but mainly in the upper Ordovician of North America, Europe and Eurasia. The common species *Protozeuga anticostiana* Twenhofel (1928, p. 213, pl. 21, figs 15-17), was assigned by Schuchert and Cooper (1930, p. 280) to *Cyclospira* on the basis of muscle impressions in the moulds. Cloud (1942, p. 146) revised this species and also assigned it to *Cyclospira* because there is no jugum; however, Dr P. Copper informs us that a jugum is present. *C.? anticostiana* occurs in the Vaureal Formation of Anticosti Island, which is of late Ashgill age; and Copper (1995) now assigns it to *Xysila*, rather than to *Cyclospira*.

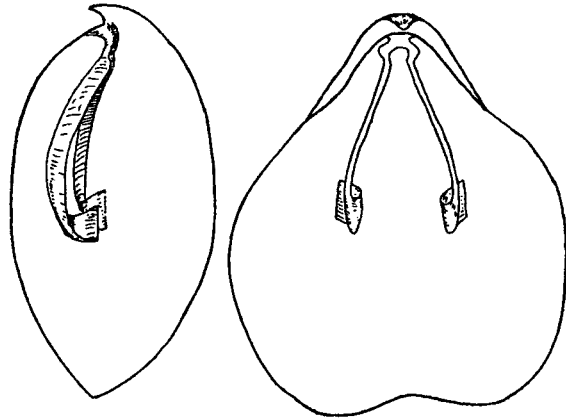
Cyclospira orbis sp. nov.

Plate 5, figures 1, 3-6; Text-figures 5-6

Derivation of name. From the Latin, *orbis* = orphaned.

Holotype. BC 51087 (Plate 5, figs 6a-e), conjoined valves, Locality 569, Bed 4.

TEXT-FIG. 6. Lateral view of a reconstruction of the spiralia of *Cyclospira orbis* sp. nov., based on the serial sections shown in Text-fig. 5.



Material. Eight conjoined and slightly damaged valves (BC 51082–51087) and one ventral valve all from Bed 4, and three pairs of conjoined valves on BC 51028 from Bed 4a.

Description. Ventri-biconvex shell with oval to rhomboidal outline, large for the genus, lacking radial ornament. The greatest thickness is at the middle valve length. A slight sulcus in both valves, leading to a dorsal sulcus and ventral fold at the anterior commissure. Beak small, incurved, very close to dorsal valve. Ventral interior with teeth supported by thin and rather short dental plates. Discrete cardinal plates joined to the thick median septum, the track of which may be visible on the external surface. Jugum absent; spiralia consisting of thin plates which turn about their axis ventrally and dorsally and continue towards the shell centre (Text-fig. 6).

Measurements (mm). Length, 6.0–9.9 mm; width, 5.5–9.3 mm; thickness, 3.8–6.0 mm.

Remarks. Among the several described middle and upper Ordovician species of *Cyclospira*, the Taimyr shells are comparatively large. The distinctive characters are the relatively low ventral elevation, visible only anteriorly, and the wide dorsal sulcus with no ventral fold. The discrete cardinal plate and the thick and rather long median septum and septarium are similar to those of *Cyclospira globosa* Rozman, 1964 (p. 189, pl. 23, figs 1–3; Rozman *et al.* 1970, p. 113, pl. 18, figs 16–20) from the upper Ordovician of north-east Russia, but the Taimyr shells are distinguished by their oval to rhomboidal outline and by the absence of a median fold in the sulcus. From *Cyclospira glansfagea* Cooper and Kindle, 1936 (pl. 52, figs 1, 4, 7) *C. orbis* is distinguished by a less convex dorsal valve and shallow sulcus without a median fold. The Taimyr shells are larger than *Cyclospira? scanica* described by Sheehan (1973) and *C. ?minuscula* Cooper (*in* Schuchert and Cooper, 1930, p. 280, pl. 2, figs 9–12).

Superfamily ATRYPOIDEA Gill, 1871
Family ATRYPINIDAE McEwan, 1939

Genus PLECTATRYPA Schuchert and Cooper, 1930

Plectatrypa? laticostata sp. nov.

Plate 5, figures 7a–e; Plate 6, figure 19; Text-figure 7

Derivation of name. From the Latin, *laticostatus* = wide ribbed.

Material. Holotype: BC 50991 (Plate 5, figure 7a–e), conjoined valves, Locality 569, Bed 4a; 36 other specimens from Bed 4a, including BC 50986–51101, and three from Bed 4, including BC 51106–51107.

Description. Biconvex and slightly transverse outline, ventral umbo moderately curved, delthyrium covered laterally by deltidial plates fusing at their base, foramen submesothyridid. Shallow ventral sulcus originating near beak, widening anteriorly and extending into a moderately high, semi-elliptical tongue. Dorsal fold variably present in the anterior half of the valve. Ornament costellate with six to nine wide ribs on the shell flanks and from one to five (usually four) ribs in the sulcus. The costae increase by bifurcation and intercalation. Concentric ornament present overall. Dorsal interior with discrete cardinal plates, supported by very short and thickened median septa (Text-fig. 7).

Remarks. This species is the most abundant brachiopod in the Bed 4a collection and also occurs in Bed 4, although there is less common than *Qilianotryma tajmyrica*. The main feature of the new species is the concentric filae which are spaced almost equally over the whole surface of the shell. Since *laticostata* is relatively coarsely ribbed and with short concentric growth interruptions and lamellae, its generic assignment is difficult. The young specimens of *laticostata* are similar to *Plectatrypa sulevi* Jaanusson and *Plectatrypa* n. sp. A of Jaanusson (1956) from the Pirgu Formation of Estonia in having one bifurcating rib in the ventral sulcus and the primary costae limited to the sulcus. The Taimyr shells are distinguished, however, by a pentagonal outline and concentric ornament from *Eospirigerina sulevi* (Jaanusson, 1956, p. 397, pl. 1, fig. 7). From *Eospirigerina porkuniana* and *E. hillistensis* from the Lower Silurian of Estonia (Rubel 1970, p. 30, pl. 14, figs 16–27; pl. 15, figs 1–10) *P.?* *laticostata* is distinguished by a more transverse outline, with the maximum width near the cardinal margin in adult specimens. From '*Plectatrypa*' sp. (Oradovskaya 1983, p. 66, pl. 17, figs 5–6), which may or may not be attributed to that atrypid genus, from the upper Ordovician of north-east Russia, it is distinguished by internal structure and greater numbers of ribs. The type species of *Plectatrypa* is *P. imbricata* (J. de C. Sowerby in Murchison, 1839) from the late Wenlock Much Wenlock Limestone Formation of England, and the species has not been properly revised, although Bassett and Cocks (1974) selected a lectotype and refigured the contemporary *P. lamellosa* from Gotland on which regular concentric frills are seen, in contrast to the true *Eospirigerina* (see below) on which concentric frills are rarely seen, and then only in fully mature specimens and near the anterior margin. It seems probable that the Silurian species of both *Plectatrypa* and *Eospirigerina* were derived from a single genus in the late Ordovician. However, the Wenlock forms of *Plectatrypa* differ quite substantially from those of the upper Ordovician, which is why we have attributed *laticostata* to the genus with a query. It is possible that, with more analysis of this multi-specific plexus through space and time, a new genus or subgenus would be appropriate which would include such Ashgill forms as *laticostata*.

Genus QILIANOTRYMA Xu, 1979

Qilianotryma tajmyrica (Nikiforova, in Nikiforova et al., 1982)

Plate 5, figure 2a–b

1982 *Euroatrypa tajmyrica* Nikiforova, in Nikiforova et al., p. 65, pl. 6, figs 1–7.

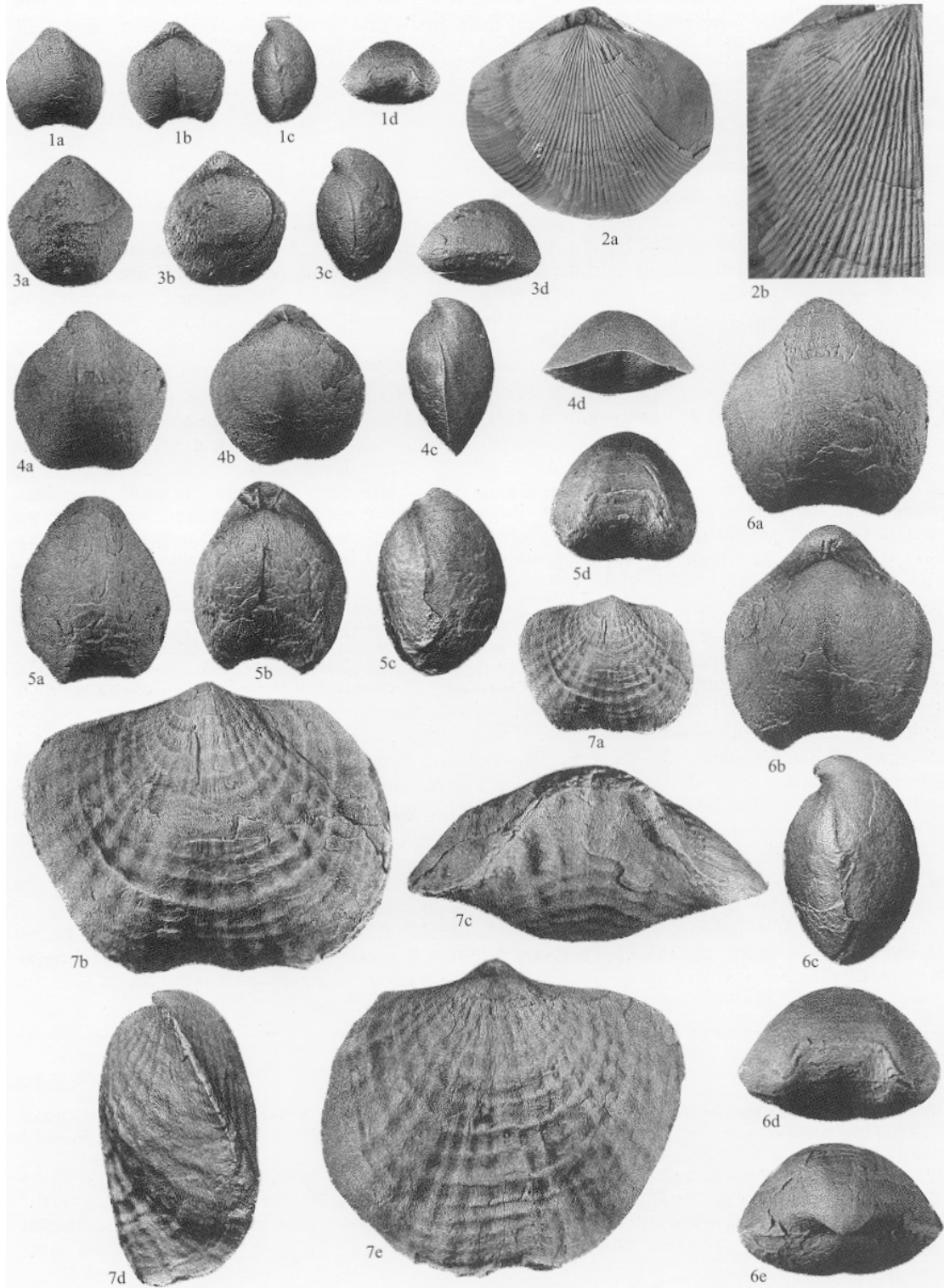
Remarks. Recent work by P. Copper (pers. comm.) has synonymized the genera *Euroatrypa* Oradovskaya, in Nikiforova et al. (1982) and the *nomen nudum* *Xenatrypa*, with type species *X. sulevi*

EXPLANATION OF PLATE 5

Figs 1, 3–6. *Cyclospira orbis* sp. nov.; Bed 4; ventral, dorsal, lateral and anterior views of five pairs of conjoined valves. 1, BC 51081. 3, BC 51082. 4, BC 51083. 5, BC 51085. 6, BC 51087, holotype, including (6e) posterior view. All $\times 3$.

Fig. 2. *Qilianotryma tajmyrica* (Nikiforova, 1982); CNIGR Museum 18/11943; Locality 542-1. 2a, dorsal view; $\times 2$. 2b, detail of ornament; $\times 5$.

Fig. 7. *Plectatrypa?* *laticostata* sp. nov.; BC 50991, holotype; Bed 4a. 7a–b ventral; 7c, anterior; 7d, lateral; and 7e, dorsal views of conjoined valves; 7a, $\times 1.5$; 7b–e, $\times 3$.



COCKS and MODZALEVSKAYA, *Cyclospira*, *Qilianotryma*, *Plectatrypa*?

from the Boda Limestone, Sweden, with *Qilianotryma* Xu (1979) from north-west China. Nikiforova recorded over 60 conjoined valves from Bed 4 and its equivalents, including specimens from locality 542-1 (Pl. 5, fig. 2a-b).

Genus *EOSPIRIGERINA* Boucot and Johnson, 1967

Eospirigerina vetusta sp. nov.

Plate 6, figures 1-18; Text-figure 8

Derivation of name. From the Latin, *vetustus* = old.

Material. Holotype, BC 50976, conjoined valves from Locality 569, Bed 4a. Other material: 42 conjoined and two ventral valves from localities 542-1 and 569, Beds 4, 4a and 6b, including BC 50969-50984 and BC 51012.

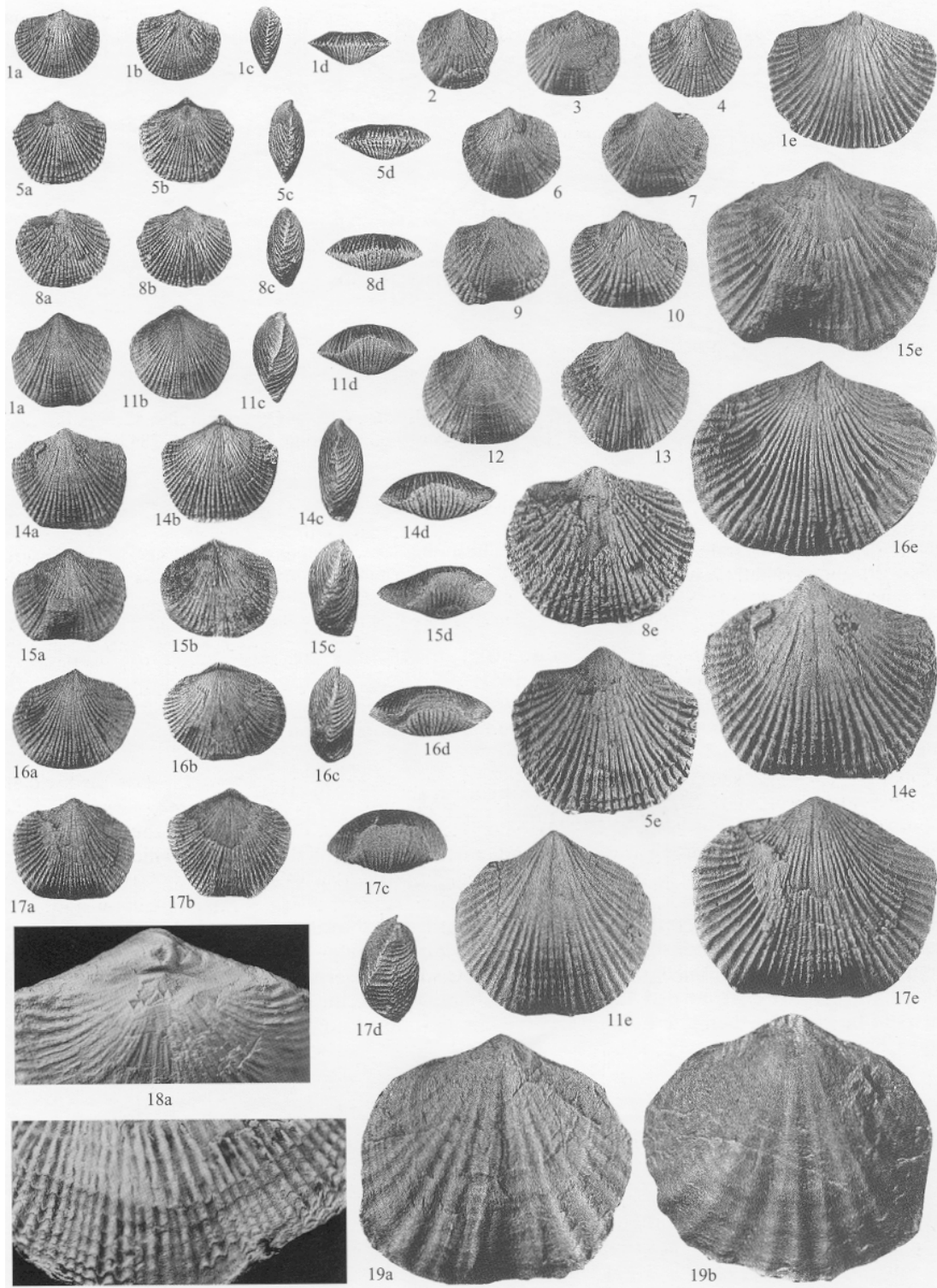
Description. Biconvex shell with sub-circular to slightly transverse outline, sometimes with extended alae, fine ribs and closely spaced uniform concentric growth filae. Maximum width near the cardinal margin. Ventral valve more convex centrally; without well-developed sulcus, but with a gently plicate anterior commissure. Beak straight or slightly incurved with submesothyridid foramen confined by small deltidial plates. Dorsal valve with uniform convexity without fold but sometimes with a shallow furrow posteriorly. The rounded to rectangular tongue is well represented on adult shells. Surface ornament of fine rounded ribs (38-48 along the anterior and lateral margins) which are increased mainly by bifurcations. Fine, closely spaced uniform concentric growth lines well preserved anteriorly. Ventral interior characterized by short, thin dental plates and stout massive teeth. Dorsal high stout myophragm elevated above the discrete cardinal plate for a short distance (Text-fig. 8). Muscle field weakly impressed.

Remarks. The type species of *Eospirigerina* is *Atrypa praemarginalis* from the late Ordovician Edgewood Limestone of Missouri, USA, which was put into the synonymy of *Zygospirella putilla* Hall and Clarke (1894) by Amsden (1974). However, *E. putilla* differs from the Taimyr material in its more closely spaced ribbing and less prominent concentric growth lines from which lamellae are only developed near the valve margin in adult shells (e.g. Amsden 1974, pl. 18, fig. 8j). The equally biconvex shells of our new species with a sub-circular outline, nearly straight cardinal lines and straight to slightly incurved pedicle beak, are similar to those of *Protatrypa malmoeensis* Boucot, Johnson and Staton, 1964 (p. 810, pl. 126, fig. 11; Copper 1995, p. 858, figs 13-15) from the Lower Llandovery of Norway. The interiors are very different, however (compare Text-fig. 8 with Copper

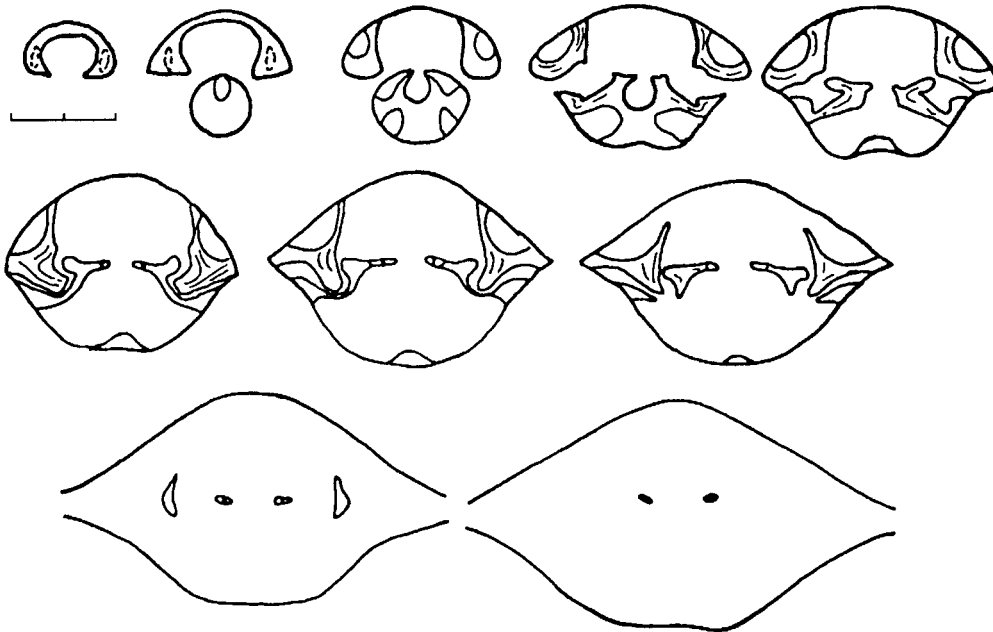
EXPLANATION OF PLATE 6

Figs 1-18. *Eospirigerina vetusta* sp. nov.; 2-4, 6-7, 9-10, 12-13, 18, Bed 4; others, Bed 4a; ventral, dorsal, lateral and anterior views of conjoined valves. All $\times 1.25$; except 1e, 5e, 8e, 11e, 14e, 15e, 16e, 17e, $\times 2.5$, and 18a-b, $\times 5$. 1, BC 50969; 2, BC 50977; 3, BC 50984; 4, BC 50979; 5, BC 50970; 6, BC 50981; 7, BC 50982; 8, BC 50971; 9, BC 50983; 10, BC 50985; 11, BC 50973; 12, BC 50980; 13, BC 50978; 14, BC 50972; 15, BC 50975; 16, BC 50974; 17, BC 50976, holotype; 18, BC 52143.

Fig. 19. *Plectatrypa? laticostata* sp. nov.; BC 50998; ventral and dorsal views of conjoined valves; Bed 4a; $\times 3$.



COCKS and MODZALEVSKAYA, *Eospirigerina*, *Plectatrypa*?



TEXT-FIG. 7. Selected transverse serial sections illustrating the development of internal structures in *Plectatrypa? laticostata* sp. nov.; length, 12.7 mm; width, 12.6 mm, thickness, 6.4 mm. Scale bar represents 2 mm.

1995, fig. 14). The regularly spaced concentric growth lines are very similar to those of *P. septentrionalis* (Nikiforova and Andreeva 1961, pl. 47, fig. 3) from the Llandovery of eastern Siberia. From *Qilianotryma taimyrica* the new species differs in the absence of a clearly defined fold and sulcus, the less incurved ventral beak, the many fewer ribs, and in the presence of concentric filae.

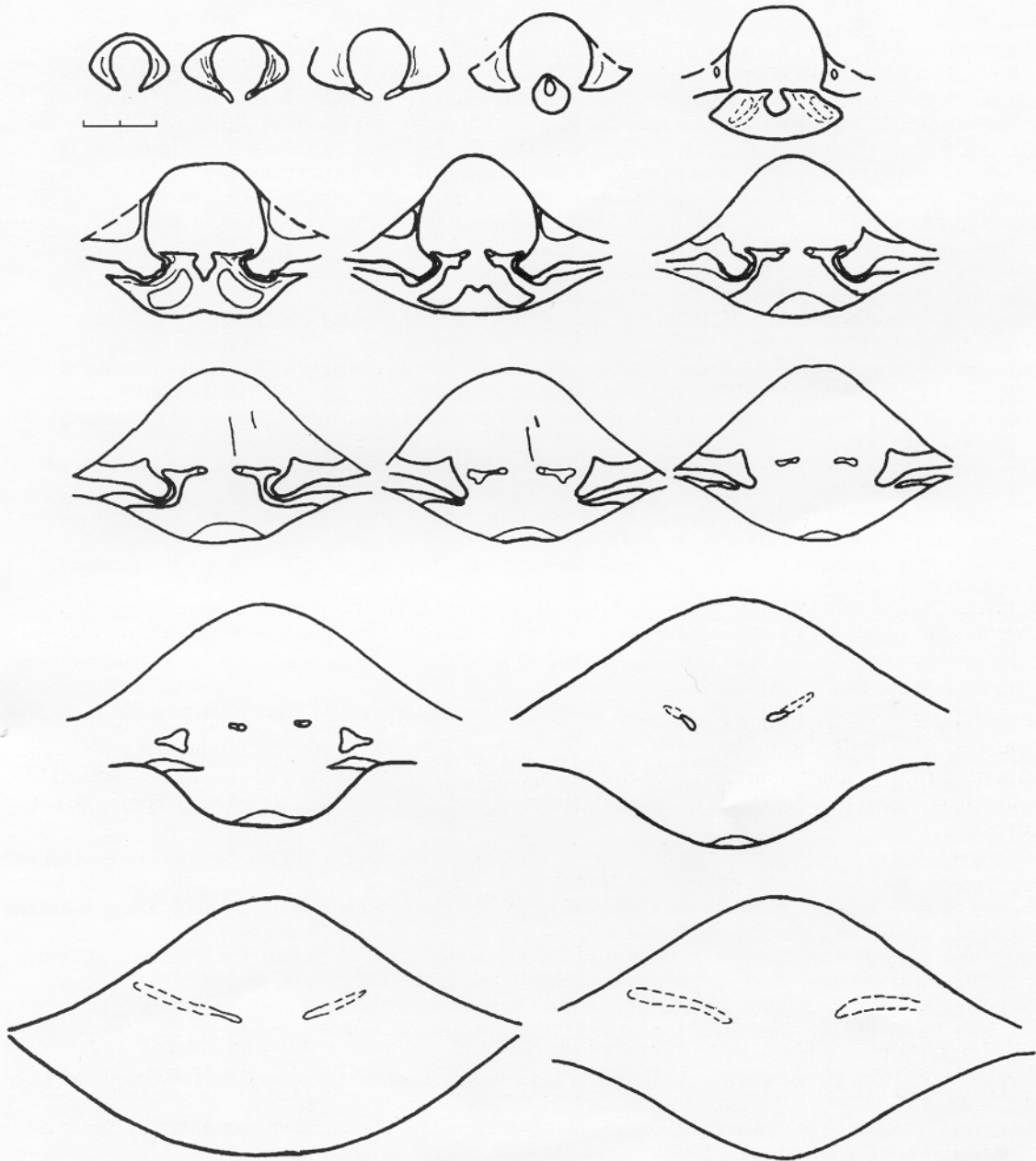
Superfamily CYRTIOIDEA Frederiks, 1919 (1924)

Family CYRTIIDAE Frederiks, 1919 (1924)

indet. cyrtiinid

Plate 4, figures 15–16

Remarks. The illustrated specimen, BC 51113 from Bed 4, showing only the exterior of a ventral valve, displays the characteristic fine radial ornament of Cyrtiidae and has an anterior median fold comparable to that of *Eospirifer*. Three less complete specimens, BC 51111 also from Bed 4, and BC 51122 and BC 51623 from Bed 4a, are also probably conspecific. Although considered for many years to be no older than late Llandovery, the family is now known from the Ashgill of Tasmania and China.



TEXT-FIG. 8. Selected transverse serial sections, illustrating the development of internal structures in *Eospirigerina vetusta* sp. nov.; length, 14.3 mm; width, 16.3 mm; thickness, 7.75 mm. Scale bar represents 2 mm.

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