

Brachiopods and trilobites from the Ordovician Lower Hovin Group (Arenig/Llanvirn), Hølanda area, Trondheim Region, Norway: new and revised taxa and paleogeographic interpretation

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Thirteen brachiopod and 13 trilobite taxa in 15 collections from the Hølanda Limestone and Nyplassen Formation of the Lower Hovin Group confirm the late Arenig-early Llanvirn age of these rocks. New monotypic and apparently endemic brachiopods are: the taffiid *Chaloupskia scabrella* n.gen., n. sp.; the leptelline *Bockelia angusticostata* n.gen. n.sp.; and the syntrophopsid *Rhabdostrophia striatisculpta* n. gen., n. sp. The new leptelline genus, *Vehnia* (type species, *Chonetoida triangularis* Reed) also occurs in northwestern Ireland. The trilobites *Blosyropsis* cf. *B. billingi* Whittington and *Ectenonotus* sp.indet. are newly recorded from these rocks; specific affinities of two trilobites, *Illaenus* sp. cf. *auriculatus* Ross, and *Calyptaulax* cf. *C. incepta* Whittington are established. Similarity with North American assemblages is supported by co-occurrence of 8 brachiopod taxa here and in Nevada and western Newfoundland, and 12 of trilobite taxa from these areas and from Spitsbergen.

The superposition of the Lower Hovin Group above volcanic rocks correlated with the Løkken Group indicates their insular origin. The fossils and the rocks that contain them show that this island or island complex lay offshore from the Laurentian craton, at a low latitude in a tropical to subtropical climatic realm.

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Introduction

Thirteen brachiopod taxa described and classified according to contemporary standards are now known from 15 places along 13 km of outcrop belt in the Hølanda area, Trondheim Region, west-central Norway, 14 from calcareous siltstone associated with the Hølanda Limestone of the Lower Hovin Group sequence, and one from tuffaceous shale of the Nyplassen Formation. Six of these belong to genera peculiar to assemblages of Whiterock age in Nevada, USA and Newfoundland, Canada. Four belong to genera and species that are apparently endemic, three of which are newly erected here, and one is a species previously described from this area that was recently reported from northwestern Ireland (Harper *in* Harper et. al *in* press) for which a new genus is erected herein. A few specimens belong to an unnamed species of two cosmopolitan genera. Although trilobites are less numerous and less well preserved than the

brachiopods, representatives of 11 genera have been recognized. Ten of these, excepting *Sphaerocoryphe* (Bruton *in* Neuman & Bruton 1974), also occur in rocks of Whiterock age in Nevada, U.S.A., western Newfoundland, Canada, and on Spitsbergen. This additional information supports the long-held view that the brachiopod and trilobite assemblage of the Lower Hovin Group is more like contemporaneous assemblages of North America than those elsewhere in Scandinavia.

Conodonts confirm the North American faunal affinities of the Hølanda Limestone and indicate its correlation with the early Middle Ordovician *Anomalorthis* Zone of the Whiterock Stage (or Series) in Nevada (Bergström 1979), correlated with the upper part of the British Arenig Series and the lower part of the Llanvirn Series. Coeval graptolites of the Bogo Shale, immediately southwest of the Hølanda Limestone also have North American (Pacific

province) affinities (Schmidt 1984, and references therein).

The sequence of rocks in which the fossils occur, together with the presence of brachiopods not known in North America suggest that the rocks and fossils of the Lower Hovin Group are not a fragment of the North American continental margin, but that they accumulated offshore from the North American continent.

Like our earlier report on the fossils from one sample in this area (Neuman & Bruton 1974), this one consists of three parts: the introductory section under joint authorship, followed by a section on the Brachiopoda by Neuman, and one on the Trilobita by Bruton. Similarly, in the systematics sections suprageneric classifications largely follow those of Harrington et al. (1959) and Williams et al. (1965), and reference to sources of names used therein are not listed in the references.

Geology and source of the brachiopods and trilobites

The Hølonnda area has been of special interest to geologists since its fossils were first reported by Brøgger (1875; for a brief account of early work in the area see Vogt 1945). Although various interpretations of the area were later offered by other geologists, detailed mapping that was begun by Kiær remained incomplete when he died in 1931. His description of the rocks of the area and seven papers on its fossils were published posthumously (Kiær 1932), leaving many questions of geologic relations and stratigraphy unresolved. Vogt's (1945) geologic map of a part of the Hølonnda—Horg district at 1:40,000 scale was an important step toward our present understanding of the areas, as was Chaloupsky's (1977) map at 50,000 scale of a much larger area. More recently, geologic investigations of small areas near Løkken and near Hølonnda were conducted simultaneously. Both resulted in 50,000-scale maps, the former supplemented by new information concerning the graptolites (Ryan et al. 1980), the latter (Bruton & Bockelie 1980) leading to the discovery of most of the localities that yielded the fossils that are discussed herein. Further studies in the area by Roberts et al. (1984) and Walsh (1986) have brought increased understanding of its geology.

A stratigraphic classification that conforms to present-day conventions has not yet been agreed on, but the main outlines of the relations of its constituent parts is becoming apparent (Table 1). A thrust-fault first mapped by Chaloupsky (1977) and Bruton & Bockelie (1980), and later by Walsh (1986) who named it the Horg Fault, separates two sequences of sedimentary rocks and contrasting suites of ophiolitic rocks. The fossiliferous Lower Hovin Group sequence of Arenig—Llanvirn age and related sedimentary rocks and the Løkken, Grefstadjfjell, and Vassfjell ophiolitic rocks that underlie them form the upthrown block to the northwest of that fault. The brachiopods and trilobites treated in this paper came from the Lower Hovin Group and coeval rocks in this structural setting.

The classification suggested here identifies the volcanic rocks at the base of the sequence of sedimentary rocks in the area of Figure 1 as 'Greenstone complex'. These rocks were considered to belong to the Støren Group by Bruton & Bockelie (1980) and their predecessors. It is now apparent, however, that they are contiguous with the Vassfjell ophiolite complex, which is correlated with the Løkken (Løkken Formation of Ryan et al. 1980) and Grefstadjfjell ophiolite complexes (Roberts et al. 1984), classified as Group II ophiolites of Ordovician age by Furnes et al. (1985). The Lo Formation that contains graptolites of Castlemain 2 to Yapeen 1 (mid-late Arenig) age was considered by Ryan et al. (1980) to lie stratigraphically beneath the Løkken Formation, but this interpretation has been contested (Heim et al. 1987). The Arenig age of the Løkken Formation is known from mid- to late Arenig graptolites in shale interbedded with its pillow lavas (Ryan et al. 1980).

The sequence in the upthrown side of the Horg Fault to the west of the Hølonnda Church (Ryan et al. 1980) includes some rocks that are coeval with those east of the church, and some, such as those of the Lo Formation, are older. The contrasting character of the coeval rocks of the two areas is reflected in the different local names used for them (Table 1; Chadwick et al. 1962, Ryan et al. 1980). West of the Hølonnda Church, black shale of the Bogo Formation, above volcanic rocks of the Grefstadjfjell ophiolite complex contains graptolites of Yapeen 3 to Darriwil 2 (late Arenig — early Llanvirn) age (Schmidt 1984), coeval with the Hølonnda Limestone (Bruton & Bockelie 1980).

	Chadwick et al. 1962	Ryan et al. 1980	This paper		Chaloupsky 1977	Vogt 1945
Caradoc-Ashgill		Høgknippen Formation Ryanda Formation Kalstad Limestone		Upper Hovin Group sequence Felsic volcanic & volcanoclastic rocks e. g. Espehaug Rhyolite, Grim-såsen & Hareklett Tuffs; locally includes limestone (e.g. Kalstad Limestone) Volla Conglomerate Dicranograptus Shale	Sandå Group (upper) Calcareous sandstone, quartzite, conglomerate Sandå Group (lower) Tuffaceous sandstone & banded slate Limestone Polymict conglomerate FAULT	Horg Series Sandå Shale Lyngestein Conglomerate
		UNCONFORMITY	HORG FAULT (after Bruton & Bockelie 1980)	???	Krokstad Group Hølonða Porphyrite Green-grey graywacke, sandstone, slate & siltstone Gaugstabbakk Breccia Hølonða Limestone Lower sandstone Greenstone conglomerate & breccia	Hovin Series (upper) Hovin Sandstone Grimsås Rhyolite Volla Conglomerate
Arenig-Llanvirn	Nyplassen Beds Fjeldheim Beds (includes Bogo Shale)	Nyplassen Formation Bogo Formation Løkken Formation Lo Formation	Lower Hovin Group sequence Tuff & conglomerate (channel fill) 'Porphyrite' Hølonða Limestone Shale Sandstone Venna Conglomerate 'Greenstone complex' Base not exposed	Krokstad Formation ???	UNCONFORMITY	Hovin Series (lower) Dicranograptus & Tomme Shales Esphaug Tuff Hareklett Tuff Sundsetkjølen Tuff Svartjern Limestone Krokstad sandstone, shale, etc., includes Hølonða Limestone Venna Conglomerate
Pre-Arenig	Støren Group			Støren Group	Støren Group	Støren Series

Table 1. History of stratigraphic nomenclature in the Løkken-Hølonða-Hovin area. Løkken area names in left-hand columns, Hølonða-Hovin names on the right. Candidates for formal recognition in bold face type. Units listed under 'Upper Hovin Group sequence' in 'This paper' column may include synonyms.

The Nyplassen Formation, a heterogeneous unit of volcanoclastic and epiclastic rocks, has brachiopods in splintery, tuffaceous shale at one place (locality A of this paper) that are like those of the Hølonða Limestone.

The downthrown block southeast of the Horg Fault contains the fossiliferous Upper Hovin Group sequence of Caradoc-Ashgill age, underlain by the Krokstad Formation, a thick (~ 400 m according to Chaloupsky 1970) sequence of unfossiliferous sedimentary rocks traditionally assigned to the Lower Hovin Group, that in turn is underlain by ophiolitic volcanic rocks of the Støren Group (Chaloupsky 1970, 1977, Furnes et. al. 1985, Stephens & Gee 1985). The term Lower Hovin Group

has thus been used for two contrasting sequences that are now known to be structurally disjunct. The rocks that yielded the fossils discussed in this paper may or may not be coeval with the Krokstad Formation.

The Upper Hovin Group sequence, on the downthrown (southeast) side of the Horg Fault, contains Caradoc and Ashgill-age fossils, to be treated in a later paper. These fossils were collected from several places within and beyond the area of the Hølonða map sheet (Bruton & Bockelie 1982) but the rocks that contain them have not been investigated as intensively as were those north of the Horg Fault. The Krokstad Formation, beneath the Upper Hovin Group has long been assign-

ned to the Lower Hovin Group, but its age and relations to the Lower Hovin Group northwest of the Horg Fault remains to be determined. The Krokstad Formation is underlain by greenstone of the Støren Group. The ophiolitic Støren Group is one of several such bodies classified as Group I ophiolites by Furnes et al. (1985) that are considered to be older than those of Group II. Distinction of these two groups of ophiolites has profound implications for determining the paleogeographic settings of the contrasting sedimentary sequences that overlie each of them. These differences confirm the suggestion that the Upper Allochthon of the Scandinavian Caledonides consists of several terranes, two of which are in juxtaposition here. One of these consists of the pre-Arenigian Støren Group overlain by a cover sequence consisting of the undated Krokstad Formation and the Caradoc/Ashgill-age Upper Hovin Group; the other contains the Arenig-age Løkken Group and the Arenig/Llanvirn-age Lower Hovin Group sequence. The great allochthoneity of the Lower Hovin Group sequence is indicated by its abundant limestone and by the abundance of fossils that are characteristic of coeval warm-water shelf sequences, indicating that the sedimentation of the Lower Hovin Group sequence shared the warm-water, low-latitude environment that governed the faunal content and the sedimentation of the Table Head Group on the carbonate bank of the Laurentian miogeocline.

The composition of the Hølonde area 'Porphyrite' (Fig. 1) that was intruded penecontemporaneously with sedimentation of the Lower Hovin Group (Bruton & Bockelie 1980) indicates that the sedimentary sequence was deposited on obducted oceanic crust (Roberts et al. 1984), a setting that is significantly different from that of the continental crust that underlies the Table Head Group. Inferences drawn from the rocks and fossils of the Lower Hovin Group and related coeval rocks such as those on Smøla in Norway (Bruton & Bockelie 1979, Bruton & Harper 1985), and in the South Mayo trough of northwestern Ireland (Williams & Curry 1985) suggest that all belong to one or more suspect terranes that originated from within the same low-latitude paleoclimate zone, far from the cooler-water, mid- to high-latitude climate zone of autochthonous European Ordovician miogeoclines (Van der Voo 1988).

Occurrence and significance of the brachiopods and trilobites

The 13 brachiopod taxa identified in this study were taken from samples of calcareous siltstone at 15 localities, 13 of which are in or near limestone of the Lower Hovin Group mapped by Bruton & Bockelie (1980; see Fig. 1), and two are from similar rocks west of the mapped area. The 13 trilobite taxa were associated with the brachiopods at five of these localities. The largest samples came from the vicinity of three previously known localities: (a) the Vehn (or Ven) farm localities 1, 2, 3 of Fig. 1 and Table 2); (b) the mountain Katugleåsen (localities 4, 5), both in the immediate vicinity of localities listed by Reed (1932) as containing the older of two «...rather distinct assemblages...», and (c) the Trotland farm (localities 11, 12, 13) near the locality discovered by Vogt that yielded fossils described by Strand (1948), Bockelie (1974), and Neuman & Bruton (1974). The fossils from locality B are in calcareous siltstone interbedded with limestone about 1.8 km west of the Bruton and Bockelie map area; this locality was discovered by Chaloupsky (1977) and newly collected for this report. The tuffaceous shale of locality A, 2.6 km southwest of Locality B, was first collected by Chadwick (Dean *in* Chadwick et al. 1963); it is 0.3 km east of the eastern edge of the northern outcrop belt of the Nyplassen Formation of the Løkken—Meldal map area (Ryan et al. 1980).

The utility of collections from so many places becomes apparent on inspection of the tabulation of the number of specimens of species identified from collections at each locality (Table 2). Large numbers of specimens from some localities reflect specific efforts to exploit the more promising occurrences, but collections as small as a single specimen that were made in the course of the mapping program are recorded here. Species diversity in the six larger collections (>50 specimens) ranged from 2 to 9 of the 13 species, and species dominance (specimens of the most abundant species as a percentage of the total number in the collection from that locality) ranges from a low of 40% (*Chaloupskia scabrella*) at locality A to 70% (*Vehnia triangularis* at Localities 1 and 6; *Aporthophyla stoermeri* at Locality B). The dominance of *Trondorthis strandi* in the Trotland Farm sample (Locality 12 of this paper; Neuman & Bruton 1974)

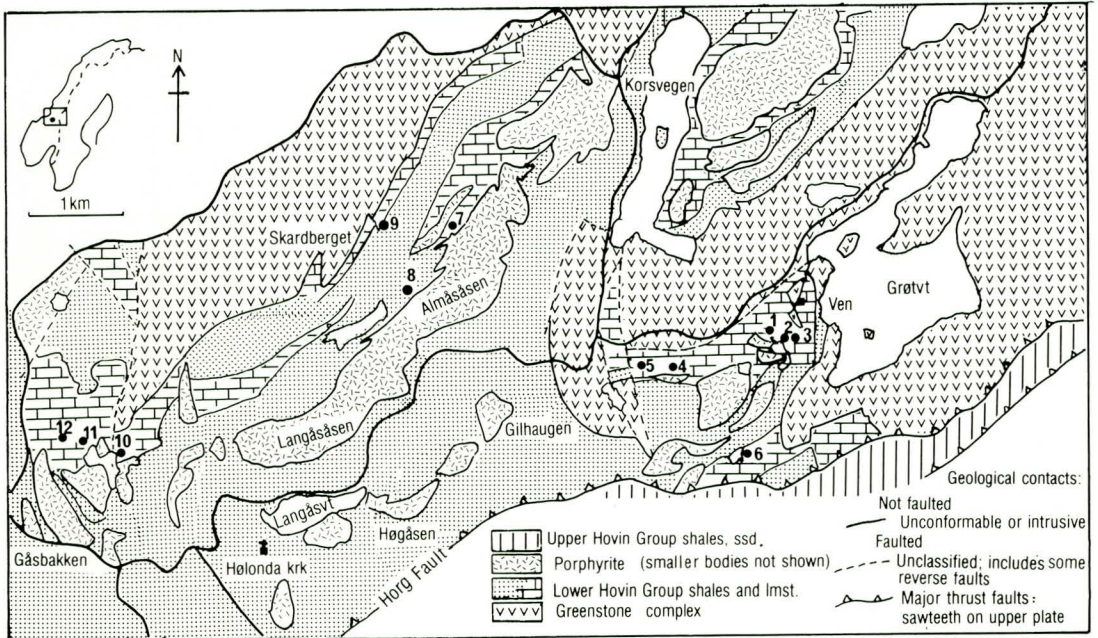


Fig. 1. Geologic map of the Hølonnda area showing location of outcrops from which brachiopods and trilobites were collected. Map compiled by D.L. Bruton from field maps and data provided by J.F. Bockelie, B.T.G. Wandås, & S. Ilebakk.

is not repeated at other localities, nor were additional specimens found of the brachiopod identified in that paper as a finkelnburgiid?

Two of the new species described here (*Bockelia angusticostata* and *Rhabdostrophia striatisculpta*) are known only from westernmost localities. *B. angusticostata* is unique to Locality A where it occurs with other more common Hølonnda Limestone fossils and *Stenocamara norvegica*, previously known from a single well preserved specimen collected by Brøgger in 1876 at 'Vestre Katuglås', near Locality 5. *R. striatisculpta* is unique to the Nyplassen Formation at Locality B where it is associated with abundant and well preserved specimens of *Aporthophyla stoermeri*.

The most common species is *Syndielasma katuglasensis*, identified in collections from eight localities, followed by *Aporthophyla stoermeri*, *Chaloupskia scabrella*, and *Rhysostrophia* sp., each identified in collections from seven localities.

Little opportunity was afforded to determine the taphonomy of the brachiopods but two samples that preserve small areas of shelly bedding surfaces permit some insights (Fig. 3, 4Y). Both record rapid burial of living popula-

tions (biocoenoses), judging from the abundance of articulated valves, their wide size range and weak orientation (Fig. 2a,b). Both samples warrant comment, but their orientation in space is not known, limiting the applicability of information obtainable from them. Both samples are cut by spaced cleavage, but the brachiopods are essentially undeformed.

The larger sample (Fig. 3), from, Katugleåsen (Locality 5), is a cast of the underside of a bedding surface exposed in an overhanging ledge of calcareous siltstone, part of a sequence whose probable normal order (not overturned) is confirmed by the orientation of the brachiopods. Cleavage intersects the bedding surface at about 40°. The fossiliferous surface is interpreted to be the imprint of the upper surface of the now-eroded underlying bed. Forty-eight brachiopod shells, a few fragments of unidentified ramose bryozoans, and a column of articulated pelmatozoan stem plates on this surface are considered for taphonomic analysis (Fig. 2a). Sixty percent (29) of the brachiopods are specimens of *Chaloupskia scabrella*, that range in length from 5 to 11 mm (see 'Systematic paleontology' section).

BRACHIOPODS	1	2	3	4	5	6	7	8	9	10	11	12	13	A	B	t
<i>Archaeorthis?</i> sp.	59	--	--	4	14	--	--	--	--	--	--	--	--	--	--	77
<i>Ortkambonites</i> sp.	--	1	--	--	33	--	--	--	--	--	--	--	--	--	--	34
<i>Trondorthis strandi</i>	6	--	3	--	19	--	--	--	--	--	--	--	145	3	--	176
<i>Aporthophyla stoermeri</i>	--	--	2	1	1	1	1	--	--	--	--	--	49	3	36	94
<i>Chaloupskia scabrella</i>	--	--	--	--	194	13	--	1	--	3	--	--	--	48	--	259
<i>Bockelia angusticostata</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	41	--	41
<i>Syndielasma katuglasensis</i>	--	--	20	--	13	--	2	3	--	--	1	1	93	2	--	135
<i>Vehnia triangularis</i>	200+	--	5	--	52	37	--	--	--	--	--	--	--	6	--	300
<i>Trotlandella loki</i>	--	1	--	--	--	--	--	--	--	--	--	--	34	--	--	35
<i>Rhabdostrophia striatisculpta</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	16
<i>Rhysostrophia vagans</i>	16	13	--	26	4	--	--	--	1	5	--	3	--	11	--	79
<i>Idiostrophia</i> sp.	1	--	--	--	--	--	--	--	--	--	--	4	--	--	--	5
<i>Stenocamara norvegica</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	4	--	4
Total brachiopods	282+	15	30	34	327	51	3	4	1	8	1	8	321	118	52	1255+
TRILOBITES										10A						
<i>Niobe vogti</i>	--	--	--	--	--	--	--	--	--	--	--	--	2	--	--	2
<i>Isoteloides</i> sp. indet.	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	1
<i>Nileus</i> sp. indet.	1	--	--	--	--	--	--	--	--	--	--	--	1	--	--	2
<i>Blosyropsis</i> cf. <i>B. billingsi</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	1
<i>Goniatelina broeggeri</i>	--	--	--	--	5	--	--	--	--	--	--	--	5	--	--	10
<i>Bathyurid</i> gen. & sp. indet.	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	1
<i>Ilaenus</i> cf. <i>I. auriculatus</i>	--	--	6	--	4	--	--	--	--	--	--	--	--	--	--	10
<i>Ilaenus</i> sp. indet.	--	--	1	--	1	--	--	--	--	--	--	--	--	--	--	2
<i>Ectenonotus</i> sp. indet.	--	--	2	--	--	--	--	--	--	--	--	--	1	--	--	3
<i>Pliomerid</i> gen. & sp. indet.	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	1
<i>Sphaerocoryphe</i> sp. indet.	--	--	--	--	--	--	--	--	--	--	--	--	6	--	--	6
<i>Cheirurid</i> gen. & sp. indet.	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	1
<i>Calyptraux</i> cf. <i>C. incepta</i>	--	--	--	--	--	--	--	--	--	1	--	--	3	--	1	5
Total trilobites	1	--	9	--	10	--	--	--	--	1	--	--	22	--	2	45

Table 2. Census of brachiopods and trilobites from 'Lower Hovin Group' localities considered in this study.

Locality descriptions: numbered localities shown in Fig. 1; lettered localities A & B are west of the area included in that figure.

1. Lane to Damtjern, 50 m north of path to dam, GR 572 014; Neuman & Bruton collection 1 of 30 September, 1970.
 2. Damtjern, south end of wall marking dam, GR 572 013; Bruton & Bockelie collection 28, of 26. May, 1975; vicinity of sample yielding conodonts (Bergström 1979).
 3. Damtjern, small outcrop in wood about 100 m east of dam wall, GR 574 014; Bruton & Bockelie collection 48 of 27. May, 1975 and 17. June, 1980.
 4. Northern edge of Fjøsåsen, GR 561 010; Bruton & Bockelie collection 19 of 25. May, 1975.
 5. Katugleåsen, southeastern slope, 4 m above base of 'Damtjern Shale', GR 566 008; Bruton & Bockelie collection 66B of 28 May, 1975, additional collection by Bruton, Bockelie & Neuman, 17. June, 1980. *See also* Bruton & Bockelie (1982, p. 89) field trip stop 5:7; vicinity of sample yielding conodonts (Bergström 1979).
 6. Kjølvegen, east side of Nedrekåstjern, GR 572 999; Bockelie & Wandås collection 126 of 1976.
 7. Svarttjørnmyra, GR 538 025; Bockelie & Illebekk collection 351 of 1977.
 8. Hårråsåsen, GR 535 021; Bockelie & Illebekk collection 369 of 1977.
 9. Gåsland, GR 530 023; Bockelie & Illebekk collection 548 of 1977.
 10. Lykkja, lane and brook ~125 m SW of farmhouse, GR 522 012; Bockelie & Illebekk collection 314 of 1977; additional collection by Bruton, Bockelie, & Neuman, 16. June, 1980; 10A, 60 m E of 10 (GR 522 018), Neuman collection of 22. June, 1980.
 11. Stensvatnet, GR 502 000; Bockelie & Illebekk collection 395 of 1977.
 12. East of Trotland; GR 495 004; Bockelie & Illebekk collection 545 of 1977.
 13. Trotland of Neuman & Bruton (1974), GR 491 005; collected in 1970.
- A. Bjørnliatnet, GR 457 956 (6.3 km 250° of Hølonde Church); tuffaceous shale adjacent to lane north of eastern part of pond; first reported by Chadwick et al. (1963) in Nyplassen Beds (=Nyplassen Formation of Ryan et al. (1980); collected by Neuman, Grammelvedt, & Bruton 28. September, 1970, and by Bruton, Bockelie & Neuman 19. June, 1980.
- B. Østlund, GR 473 988 (4.5 km 270° of Hølonde Church); calcareous siltstone beneath limestone adjacent to lane about 100 m NE of farmhouse; vicinity of locality 'St. Fluglås' of Chadwick et al. 1963, identified by symbol on map by Chaloupsky (1977), collected by Bruton, Bockelie & Neuman, 19. June, 1980.

Distinction between articulated and disarticulated valves is not possible for those specimens partly covered by sediment, but at least 10 are certainly articulated, and the dorsal valves of 7 of these face upward. At least half of the specimens (all species) are disarticulated. The plot of the orientation of the 48 shells (all species) shows that only 7 specimens are oriented within 30° of the arbitrary 90° - 270° axis of the plot, but fragments of ramose bryozoans and the column of articulated pelmatozoan stem plates lie in this orientation. By contrast, 28 specimens (58% of the total) lie within 30° of the 0°-180° axis of the plot. Because the plectambonitaceans *C. scabrella* and *S. katuglasensis* probably lacked a functional pedicle during adulthood, they probably lived unattached on the sea floor. Specimens whose dorsal valves faced upward probably fare better than those oppositely oriented, and those that opened into the prevailing currents may have had advantageous access to nutrients. This bedding surface seems to preserve the combination of living and dead shells that might be expected of a living population in a small sample of the sea floor. The specimens that were buried alive were more or less favorably oriented by the same weak currents (0°-180° arbitrary orientation) that governed the resting places of the dead ones.

A small cluster of *Archaeorthis?* sp. buried in life position is preserved in the smaller sample (Figs. 2b; 5Y) from Locality 1, Damtjern) but the position of this sample with regard to bedding sequence is not known. Cleavage in this sample is perpendicular to bedding. All specimens are articulated; they range in size (length) from 2.8 to 7.3 mm. Few lie parallel to the bedding surface; most stand at various angles to it. The beaks of some (>7) are buried in matrix, more than double the number (>3) that face in the opposite direction (upward?); the remainder lie at various intermediate positions. A plot (Fig. 2b) of the orientation of 28 specimens shows that none are oriented in the 60°-90° segment, 25% lie in the 120°-150° segment, the others are more or less randomly distributed. The absence of disarticulated shells indicates that these specimens were buried alive. The wide range of their orientation suggests that they may have been gently dislodged from their normal living positions shortly before burial. That currents were commonly gentle is confirmed by the near absence of disarticulated valves of *Veh-*

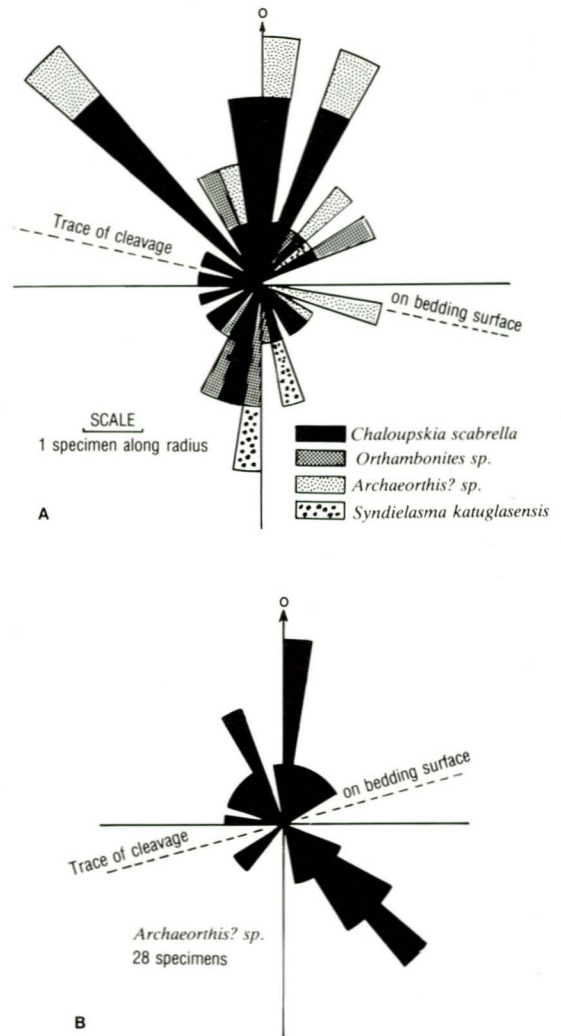


Fig. 2. Circular histograms showing orientation of brachiopods: A - *Chaloupskia scabrella*, 29 specimens; *Archaeorthis?* sp., 8 specimens; *Orthambonites sp.*, 8 specimens; *Syndielasma katuglasensis*, 3 specimens. From Katugleåsen, Locality 5 (see Fig. 3); B - *Archaeorthis?* sp. from Damtjern, Locality 1 (see Fig. 5Y). Orientation polarity is posterior end of plane of symmetry.

nia triangularis, by far the most common brachiopod at the place from which the *Archaeorthis* sample was taken. In most places, however, articulated specimens are relatively rare, suggesting that these blocks portray a minimum of wave energy, but there are no indications of high-energy environments such as coquina shell beds or of post-mortem abrasion of shells.



Fig. 3. Silicone cast of part of the undersurface of overhanging ledge on Katugleåsen. PMO 116649. See Fig. 2A for histogram showing orientation of brachiopods. Grid ticks for location of measured specimens tabulated in descriptions of *Archaeorthis?* sp., *Orthambonites* sp., and *Chaloupskia scabrella*.

Biogeography

Previous studies of the Hølonða Limestone brachiopods and trilobites showed their affinities with those of Whiterock (Arenig-Llanvirn) age of both eastern and western North America (e.g. Spjeldnæs 1961; Ross & Ingham 1970; Neuman & Bruton 1974) and Hølonða Limestone conodonts indicated correlation with a specific part of the Antelope Valley Limestone in Nevada, the *Anomalorthis* Zone (Bergström 1979). The results of the present work confirm those affinities. Of the 13 brachiopod taxa now known in the Hølonða Limestone (Table 3), four (*Trondorthis*, *Aporthophyla*, *Rhysostrophia*, and *Idiostrophia*) are distinctive and characteristic components of both North America assemblages, and one (*Syndielasma*) is peculiar to the Table Head Group of western Newfoundland. (The nearly pandemic genera *Archaeorthis* and *Orthambonites*, are excluded from these comparisons.) Some Hølonða Limestone genera have also been reported from

comparable coeval assemblages elsewhere. In Ireland *Vehnia*, *Rhysostrophia*, and *Idiostrophia* are known in the South Mayo Trough sequence from the Mweelrea Group. Although the Tourmakeady Beds of this sequence have many genera in common with the Antelope Valley Limestone (Williams & Curry 1985), none (but *Orthambonites*) is a Hølonða Limestone congener. *Rhysostrophia* and *Idiostrophia* in the Khitinskaya and Elgenskaya Suites of northeastern U.S.S.R. are two of several brachiopod genera that indicate their White-rock age (Orodovskaya in Chugaeva et al. 1973) but most of their genera are different from those of the Hølonða Limestone. Similarly, among the several genera reported from limestone on Jolmo Lungma (Mount Everest) in the Himalayas (Liu 1976; Ross 1984), *Aporthophyla* is the only Hølonða Limestone congener. *Stenocamara* in both the Hølonða Limestone and the Skjølberg Limestone of Smøla (Harper 1981) is slightly older than in North

	1	2	3	4	5	6
<i>Archaeorthis? sp.</i>	-	D	FG	HIJ	L	-
<i>Orthambonites sp.</i>	-	D	-	HIJK	-	M
<i>Trondorthis strandis</i>	-	-	G?	HJ*	-	-
<i>Aporthophyla stoermeri</i>	A	-	FG	HJ	-	M
<i>Chaloupskia scabrella</i> endemic					
<i>Bockelia angusticostata</i> endemic					
<i>Syndielasma katuglasensis</i>	-	E?	-	HJK	-	-
<i>Vehnia triangularis</i>	-	E	-	-	-	-
<i>Trotlandella loki</i> endemic					
<i>Rhabdostrophia striatisculpta</i> endemic					
<i>Rhysostrophia vagans</i>	-	C	FG	HIJK	L	-
<i>Idiostrophia sp.</i>	-	C	FG	HJK	L	-
<i>Stenocamara norvegica</i>	B	-	-	I	-	-

* ex *Orthambonites bifurcatus* Cooper, 1956

Table 3. Occurrence of congeners of 'Lower Hovin Group' brachiopods in related assemblages elsewhere.

Sources:

- 1 — Smøla, Norway - Skjølberg Limestone: A = Bruton & Bockelia (1979); B = Harper (1981).
- 2 — Western Ireland - C = Mweelrea Group: Williams (1972); D = Tourmakeady Limestone, Glensaul Group: Williams & Curry (1985); E = Glenummera Group: Harper et al. (in press 1989).
- 3 — Western Newfoundland - Table Head Series/Group: F = Cooper (1956); G = Ross & James (1987).
- 4 — Western Nevada, southeastern California — H = Pogonip Group: Cooper (1956); I = Badger Flat Limestone (California) and Antelope Valley Limestone, California and Nevada: Ross (1967); Antelope Valley Limestone, Nevada: J = Ross (1970); K = Ross (1972).
- 5 — Northeastern U.S.S.R. - L = Khitinskaya and Elgenchakskaya Suites: Orodovskaya in Chugaeva, Ivanova, Orodovskaya, & Yakolov (1973).
- 6 — Jolmo - Lungma (Mt. Everest), China - M = Jolmolungma Formation: Liu (1976).

American occurrences (Mosheim Limestone in the southern Appalachians, *vide* Cooper 1956; *Stenocamara?* in post-*Anomalorthis* Zone, uppermost Antelope Valley Limestone, Nevada Test Site section of Ross 1967).

The scattered distribution of Whiterock brachiopod and trilobite assemblages of this kind (Toquima-Table Head faunal realm of Ross & Ingham, 1970), is consistent with the previously held view that the rocks containing them shared a low-latitude warm-water environment (Cocks & Fortey, 1982; Neuman, 1984). Those of North America are parts of peri-continental

sequences, as perhaps are those in Siberia and Tibet, but the geologic context of the Irish South Mayo sequence, Smøla, and Hølonða indicate their deposition in oceanic settings as suggested by Neuman (1984), Bruton & Harper (1985), and Neuman & Max (1989). The relatively high percentage of endemic brachiopod genera also suggests such isolation: 8 of 23 (35%) new endemic genera of Articulata in the Irish Tourmakeady Limestone (Williams & Curry 1985) 3 of 13 (23%) in Hølonða Limestone assemblage, plus one new genus known also in the Irish sequence.

Of the 13 trilobite taxa now known from the Hølonða Limestone (Table 2), 9 (*Niobe*, *Isoteloides*, *Blosyropsis*, *Goniotelina*, *Iliaenus*, *Ectenonotus*, *Calyptaulax*, a cheirurid, and a pliomerid) are recorded from rocks of Whiterock age in Nevada, western Newfoundland, and on Spitsbergen; *Nifeus* is cosmopolitan, and *Sphaerocoryphe* is not known elsewhere until later. The *Iliaenus* of the *I. sarsi* species group (Jaanusson 1957) is also known from the Baltoscandian area, but this might be a result of convergence. For further discussion of trilobite biogeography see Neuman & Bruton (1974) and Bruton & Harper (1981, 1985).

Assignment of the fossiliferous and contiguous rock of the Lower Hovin Group to parts of an island complex remains conjectural. Low wave energy, as manifested by the taphonomy of the small, fossiliferous, calcareous siltstone samples described here, may have resulted from lagoonal sedimentation, and the massive limestone that is the more common rock of the Hølonða Limestone may represent reefal, wave-resistant, carbonate build-ups.

Brachiopoda, by R.B. Neuman

All the brachiopod specimens examined for this study belong to the Articulata whose shells were originally calcite. Most specimens studied are internal and external molds preserved in siltstone after dissolving the shells with hydrochloric acid. Thus it was possible to examine the internal features of both valves of most taxa, and to photograph these molds and replicas (in latex or silicone) made from them.

The great contrast between lists of Hølonða Limestone brachiopods compiled more than

Reed 1932	Neuman, this paper
<i>Orthis (Plesiomys) cf. porcata</i> McCoy	<i>Trotlandella loki</i> Neuman
<i>Orthis (Dinorthis) pectinella</i> Emmons?	?
<i>Orthis (Plectorthis) hovinensis</i> Reed	indet.
<i>Orthis (Valcourea?) incommoda</i> Reed	<i>Trotlandella loki</i> Neuman?
<i>Orthis (Hebertella) cf. sinuata</i> Hall	?
<i>Orthis (Nicolella) angulata</i> Reed	<i>Chaloupskia scabrella</i> n. gen., n.sp.
<i>Orthis (Horderlyella) bancrofti</i> Reed	<i>Trondorthis strandi</i> Neuman & <i>Archaeorthis?</i> sp.
<i>Orthis cf. lyckholmensis</i> Wysogorski	<i>Orthambonites</i> sp.
<i>Triplecia norvegica</i> Reed	<i>Stenocamara norvegica</i> (Reed)
<i>Triplecia</i> sp.?	?
<i>Oxoplecia dorsata</i> (Hisinger)	<i>Rhysostrophia vagans</i> (Reed)
<i>Oxoplecia vagans</i> Reed	<i>Rhysostrophia vagans</i> (Reed)
<i>Oxoplecia??</i> sp.	indet.
<i>Stropheodonta katuglasensis</i> Reed	<i>Syndielasma katuglasensis</i> (Reed)
<i>Rafinesquina semiglobosina</i> (Davidson)	?
<i>Chonetoidea triangularis</i> Reed	<i>Vehnia triangularis</i> (Reed)
<i>Leptelloidea cf. delicatula</i> (Butts)	<i>Chaloupskia scabrella</i> n. gen., n.sp.
<i>Holtedahlina? hirundo</i> Reed	<i>Syndielasma katuglasensis</i> (Reed)
<i>Zygospira cf. orbis</i> Reed	?
<i>Syntrophia cf. affinis</i> Reed	?
<i>Camarella cf. thompsoni</i> (Davidson)	?
<i>Parastrophina hemiplicata</i> (Hall) var.	<i>Idiostrophia</i> sp.
<i>Parastrophia cf. angulosa</i> (Törnquist)	<i>Idiostrophia</i> spf.

Table 4. Comparison of brachiopod identifications of Reed (1932) with those of this paper.

? = specimen neither illustrated nor available; indet. = identity of available specimen not determinable.

50 years ago by Reed and the current one (Table 4) reflects both advances in brachiopod taxonomy during that interval and more complete diagnoses of specimens available to Reed in the light of information resulting from the present study. Three specific names introduced by Reed are preserved: (1) *Syndielasma katuglasensis* (Reed) includes both '*Stropheodonta katuglasensis*' and '*Holtedahlina? hirundo* Reed' of Reed (1932); (2) *Vehnia* is a new genus erected herein to accommodate '*Chonetoidea triangularis* Reed' in the light of new knowledge of the interior of that species; and (3) '*Triplecia norvegica* Reed' is assigned to *Stenocamara* Cooper, 1956. These changes are further documented below.

Measurements are tabulated of the more complete specimens in suites of the more abundant taxa: Summaries in the text of those measurements are given in the following sequence and form: dimension measured (length, width, etc., in millimeters; see list below); number of specimens measured [in brackets]; average value for that dimension; minimum (∩) and maximum (∩) value measured (in parentheses). For example, L [23 valves] 9.5 (∩6, ∩15) signifies the average length of 23 valves is 9.5 mm, the shortest 6 mm, the longest 15mm. Abbreviations are: L=length; W=width (where maximum width is at the hinge); HW= hinge width (where less than maximum width; MW= maximum width where greater than hinge-width; L_{sc}=length of ventral muscle scars; W_{sc}=width of ventral muscle scars; T=thickness. Measurements of incompletely preserved features are followed by estimates of complete values in parentheses.

Holotypes, figured and measured paratypes, and other specimens specifically referred to have been assigned Paleontological Museum of Oslo (PMO) registration numbers. These specimens and almost all others studied for this report are deposited in that museum; a few representative specimens of the more abundant taxa have been placed in the brachiopod collection of the Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, D.C., U.S.A.

Systematic paleontology

Order ORTHIDA Schuchert and Cooper, 1932
 Suborder ORTHIDINA Schuchert and Cooper, 1932
 Superfamily ORTHACEA Woodward, 1852
 Family ORTHIDAE Woodward, 1852
 Subfamily ORTHINAE Woodward, 1852
 Genus ARCHAEORTHIS Schuchert and Cooper, 1931

Archaeorthis? sp.

Figures 3;5, U-Y.

Material. — 74 specimens from Hølonde Limestone, 50 articulated external molds from Locality 1 (Fig. 5Y); 4 articulated external molds from Locality 4, and 3 disarticulated internal molds and 11 articulated specimens from Locality 5 (Fig. 3; Fig. 5 U, V, W, X).

Description. — Small shells resembling *Dalmanella*, outline transversely suboval, maximum width near midlength, about one-fourth greater than length, and about one-fifth greater than hinge-width; cardinal angles obtuse, sides narrowly rounded, front broadly rounded. Interareas short, slightly concave, dorsal anacline, about one-fourth the length of apsacline ventral interarea, notothyrium and delthyrium open. Lateral profile ventribiconvex, maximum thickness near midlength, from one-third to one-fourth shell length; sulcus extends length of dorsal valve, moderately deep and wide at the front; ventral fold similarly well developed; anterior commissure sulcate. Radial ornament finely ramicostellate, tending to fascicostellate. Interiors poorly known, from three deformed and incomplete specimens, two dorsal valves and one ventral valve. Dorsal interior has variably developed notothyrial platform, in the larger specimen (Fig. 5 W-X. PMO 116645) a thickened pad that lacks clear evidence of a cardinal process, anterior margin of platform raised above median ridge: in the smaller specimen (not illustrated, PMO 116647) notothyrial platform has a low, thin cardinal process, and the anterior margin of the platform is not differentiated from the median ridge. Brachiophore bases stout, tops sharply pointed, fulcral plates lacking. Few significant features of ventral interior discernible in the one specimen at hand (Fig. 5, U-W. PMO 116646); teeth in completely preserved, dental plates erect, receding, sides and front of muscle area poorly defined.

Discussion. — The size, shape, proportions, and ornament of these specimens are typical of *Archaeorthis*, but their interiors are not well enough known to permit positive identification, and their assignment to the genus remains questionable. The cardinal process in one of the two dorsal valves, and the poor definition of the muscle area in the one ventral valve are inconsistent with the interiors of this genus as described. The somewhat differently oriented brachiophores in the two dorsal valves in which cardinalia are preserved may be due to differences in their deformation.

Measurements. — Listed below are dimensions of the most nearly complete specimens of silicone replicas of external molds from two places.

A — Locality 1, Fig. 5, Y, PMO 116648.

Grid location	Length (mm)	Width (mm)		Thickness (mm)	Costellae (no) at anterior margin
		hinge	maximum		
08 03	3.3 (ventral)	3.1	3.3	1.0	--
05 08	3.3 (ventral)	3.3	3.9	1.4	54
06 13	2.4 (dorsal)	2.4	3.0	-	36
11 13	2.3 (dorsal)	3.1	3.4	-	40
17 18	2.2 (dorsal)	2.3	2.9	1.7	--
19 17	2.4 (2.7) (dorsal)	1.7 (2.2)	2.1 (3.1)	1.3	~40
23 15	2.8 (ventral)	3.0	3.0 (4.0)	1.7	~40

Locality 5, Fig. 3, PMO 116649

Grid location	Length (mm)	Width (mm)	Thickness (mm)	Costellae (no)
37 48	4.0 (dorsal)	5.6	5.6	- 33
39 15	4.5 (ventral)	5.5	6.7	- 26
74 14	7.3 (dorsal)	7.0	8.3	- ~40
75 20	2.3 (ventral)	3.0	3.0	- ~30
85 37	2.8 (ventral)	3.3	3.3	- 25

Genus *Orthambonites* Pander, 1830

Orthambonites sp.

Figures 3;7, T-W.

Description and discussion. — Small to medium-size strongly costellate ventribiconvex shells, known from external molds and a few poorly preserved internal molds, all from Locality 5. Outline transversely suboval, maximum width near midlength~ 50% greater than length (L [4 ventral valves] 5.3 (>4, <8); MW 7.5 (>6.2,<15.0), cardinal extremities obtusely angular (~ 115°), sides narrowly rounded, front broadly rounded. Interareas moderately concave, short; ventral apsacline, about twice the length of dorsal anacline interarea; delthyrium and notothyrium open, unmodified. Ventral beak high, lateral and anterior profiles broadly arched, maximum thickness at about one-third shell length; fold low, obscurely distinguished from flanks. Dorsal beak low, passing forward into broad, low sulcus; sulcus sides diverge at ~ 30°, include about 4 costae at the front. Anterior commissure weakly sulcate. Radial ornament of 20—30 round, mostly unbranched, anteriorly expanding costae separated by interspaces of about similar shape, some interspaces divided by median capillae and

contain growth lines near the anterolateral margins; a few costae added by branching and insertion; costae of most specimens smaller than 3mm length unbranched, larger specimens have 4–6 costae branched near midlength, and 2–3 inserted in the same or different specimens.

Dorsal interior of the best of two specimens (Fig. 7, T-U, PMO 116650) has low notothyrial platform about one-sixth shell length, bearing a thin bladeliike cardinal process; brachiophores stout, divergent, triangular in cross-section, tips sharply pointed, sockets undifferentiated, fulcral plates lacking; broad myophragm extends from anterior margin of notothyrial platform to midlength, adductor muscle scars indistinct. Anterolateral margin marked by impressions of radial ornament, those of interspaces marked by shallow grooves.

Ventral interior of the best preserved of 5 specimens (Fig. 7, V-W, PMO 116651) has broad teeth, short receding, erect dental plates, their bases forming the posterolateral sides of the muscle field. Muscle field 20% longer than wide ($L_{sc}=1.5$; $W_{sc}=1.25$); adductor scar a little longer than diductors scars, and slightly more than twice their width. All five specimens lack internal impression of radial ornament.

Discussion. — This species is characterized by infrequent branching of its costae, together with its suboval outline and its small size. The small number of specimens, and their indifferent preservation prohibit statistical comparisons that would support adding another named species to the many of this cosmopolitan genus. Most species of *Orthambonites* have unbranched costae, and the number of costae is one of the criteria for interspecific discrimination. Only five of the 28 species treated by Cooper (1956) have branching (or inserted) ribs. Of these, *O. eucharis* (Ulrich & Cooper) from the *Orthidiella* Zone of the «upper Pogonip Group» of south-central Nevada resembles this Norwegian species, but the ribbing of *O. eucharis* is finer and more frequently branched.

The several small specimens from Locality 13, previously identified as *Trondorthis strand?* (Neuman *in* Neuman & Bruton 1974, fig. 7, L, M) is reassigned to *Orthambonites* sp. The two genera are readily distinguished by the differences in their ribbing that survives considerable deformation.

Measurements. — Dimensions of selected specimens on the bedding surface sample (PMO 116649) from Locality 5 (Figure 3) are listed below:

Grid location	Length (mm)	Width (mm)		Thick-ness (mm)	Interarea length (mm)		Costae (no.)
		hinge	maximum		dorsal	ventral	
04 31	2.7 (dorsal)	4.0	5.0	-	-		24
35 12	4.8 (ventral)	5.5	6.4	1.5		.7	27
53 42	6.7 (dorsal)	7.5	10.0		.5		28
	8.0 (ventral)					1.0	
58 39	4.5 (ventral)	5.0	6.2	1.2	2	.5	24
75 38	4.0 (ventral)	5.7	6.5	-		-	21

Order STROPHOMENIDA Öpik, 1934

Superfamily PLECTAMBONITACEA Jones, 1928

Family TAFFIIDAE Ulrich & Cooper, 1936

Genus APORTHOPHYLA Ulrich & Cooper, 1936

Aporthophyla stoermeri Neuman

Figure 7, N-S; Figure 8, A-J

□ *Aporthophyla stoermeri* Neuman *in* Neuman & Bruton, 1974

Description. — Among the 36 specimens of this species obtained from Locality B (Østlund) are several that are better preserved than those in the type suite from Trotland (Locality 13 of this paper), both in the preservation of some details, and in their lesser deformation. The original species diagnosis can thus be confirmed and amplified, supplemented by photographs of the six best specimens. The dimensions and proportions of both suites of specimens are about the same. The better preserved ornament of the Østlund specimens is consistently unequally costellate; at the front of large specimens stronger costae are irregularly spaced at 2 to 5 mm intervals with as few as 1 and as many as 8 weaker ones between them, the average spacing of weaker ones about 3 per millimeter.

Cardinalia are reasonably well preserved only in one of the smaller specimens of this lot (Fig. 7, N-Q, PMO 116652). They are like those of larger specimens previously described except for the absence of a median ridge on the notothyrial platform, and the bladeliike cardinal process that rises directly from the platform floor. The posterior adductor muscle scars of this specimen are marked by shallow depressions with crenulated posterior margins, like those of the larger specimens from the Trotland locality (Neuman *in* Neuman & Bruton 1974).

The ventral muscle fields of some of these specimens are better preserved than those previously described; in the four best specimens the muscle fields are one-third wider than long, adductor scars about equal in length to diductors, some slightly longer, others slightly shorter. A short median ridge is present at the apex of the muscle field in one of these four specimens, and in one of the eight previously illustrated.

Discussion. Ross & James (1987) questioned the generic identification of this species, and suggested its assignment to *Toquimia* because of its large cardinal process as described and illustrated (Neuman & Bruton 1974). The dorsal valve whose interior is illustrated here is smaller than those from Trotland, and it has a bladeliike cardinal process comparable to that which is normal for *Aporthophyla*. Enlargement of the cardinal process in the larger specimens may therefore be a gerontic feature of those large specimens which in every other respect have the features of *Aporthophyla*.

Measurements. —

Specimen number	Length (mm)	Width (mm)	Interarea length (mm)	Muscle field	
				length	width (mm)
PMO					
Dorsal valves					
116653	18	25	1		
116652	11	17 (19)	.7		
Ventral valves					
116654	21	31 (33)	2	6	8
116655	12	16	1.5	3	4
116656	18	24	3	5	6
116657	19	32	4	6	8

Genus *CHALOUPSKIA* new genus

Diagnosis: — Planoconvex to ventribiconvex, with chilidium and pseudodeltidium lacking apical foramen; smaller (immature) shells ramicostellate, larger ones overlain by comae; orthoid cardinalia has bladeliike cardinal process; adductor scars of ventral muscle field slightly longer than diductor scars.

Derivation of the name: — For Dr. Josef Chaloupsky, author of the bedrock geologic map of the Hølanda sheet (Chaloupsky 1977).

Type species: — *Chaloupskia scabrella* new species herein.

Species provisionally assigned. — *Taffia?* sp. Neuman 1976, p. 34–35, Pl. 7, figs. 16–21, Pl. 8, fig. 2.

Description. Medium-size, thick-bodied shells, subquadrate to semicircular in outline; profile of dorsal valve gently convex to nearly flat, slightly concave, or resupinate; ventral valve highly convex. Interareas, flat, dorsal anacline, ventral apsacline; chilidium present, its distal margin overlapped by that of imperforate, highly arched pseudodeltidium. Radial ornament of smaller (immature) shells costellate, overgrown on larger shells by comae. Taleolae (pseudopunctae) marked by widely spaced tubercles. Dorsal interior has orthoid cardinalia, with low notothyrial platform bearing a simple bladeliike cardinal process; brachiophores short, divergent; adductor scars medially separated by broad myophragm, the posterior pair lying laterad of the anterior pair through most of their length. Mantle canal system unknown. Thickened peripheral margin variably present.

Ventral interior has short, broad teeth, dental plates short, receding, muscle field of somewhat thickened shell, with broadly arcuate anterior margin, adductor scars wide, slightly longer than diductors. Mantle canal system saccate.

Discussion. — The principal feature that distinguishes this genus from other taffiids is the invariable overgrowth of comae on mature specimens. The anterolateral margins of *Taffia?* sp. of Neuman (1976) also bear comae, described as «closely spaced growth lamellae,» but evidence of pseudopunctuation was not detected in decalcified specimens or in a thin section of a portion of the fossilized shell. The presence of a chilidium and imperforate pseudodeltidium, and a persistent blade-like cardinal process also sets *Chaloupskia* apart from other taffiids.

Comae occur in plectambonitaceans of other families, such as the leptellinid *Leangella* (Öpik, 1933) and the bimurid *Bimuria* (Cooper, 1956; Williams and Rowell in Williams et al. 1965), but their function remains unknown.

Chaloupskia scabrella new species

Figures 3;6, H-V

□ *Leptelloidea* cf. *delicatula* (Butts) of Reed, 1932, p. 137-138, Pl. 21, fig. 18.

Diagnosis. — Transversely elongate shells, commonly one-third wider than long, dorsal valve nearly flat or of low convexity, ventral valve moderately and uniformly convex; ornament of smaller specimens ramicostellate, overgrown by comae in larger ones.

Derivation of the name. — From Latin *scaber* =rough.

Material. — Holotype, articulated valves, PMO 116658; 6 figured and measured paratypes, PMO 116659 — 116664, 6 unfigured paratypes, PMO 116665 — 116670; 150 paratypes neither figured nor measured, all from Hølonða Limestone, Locality 5; see Table 2 for occurrence at other localities.

Description. — Small to medium-size shells, subquadrate to semicircular in outline, widest at the hinge, width (L [23 valves] 12.5 (♂8, ♀20)) generally greater (22%) than length of longer (ventral) valve (L [23 valves] (♂6, ♀15)), ranges from 2:1 to 1:1. Cardinal extremities variably acute, most about 80°, ranging from slightly auriculate to near right-angles. Sides nearly straight, anteriorly convergent at 10°–20°, merging with broadly rounded anterior margin at 2/3 to 3/4 shell length. Profile variable, smallest shells without comae ventribiconvex, dorsal valves of somewhat larger shells with anterior overgrowth of comae resupinate, those of largest shells covered by comae nearly flat or slightly concave.

Ventral valve convexity moderate to low, uniform, shell depth ranges from about one-fourth to one-tenth shell width; maximum convexity at midlength. Fold and sulcus lacking; anterior commissure rectimarginate. Interareas short, flat planes, dorsal interarea anacline, short (1 mm or less), about half as long (2.5mm or less) as apsacline ventral interarea. Pseudodeltidium highly arched, distally overlaps distal margin of chilidium. Radial ornament preserved, largely on smaller shells, ramicostellate, costellae sharp-crested, narrower than rounded interspaces; about 9 stronger costellae extend across entire surface; intervening weaker ones inserted near beak, increase by implantation, numbering 3 to 5 at the front of large shells (~8 mm long) that lack comae. Radial ornament of larger shells mostly obscured by comae. Concentric ornament (absent comae) of fine, closely spaced growth lines. Shell surfaces, except palintrope, of most shells 8 mm and longer partially or completely encrusted comae: smaller shells (e.g. Fig. 3, coords. 40 22 and 59 51) bear comae around anterolateral margins; larger shells completely encrusted, some rugose (but note absence of comae around anterolateral margin of one dorsal valve [Fig. 3, coords. 61 45]).

Dorsal interior has short, posteriorly sloping notothyrial platform, elevated at front, about

one-third wider than long; cardinal process bladelike, highest at the front of the platform; brachiophores widely flared (~80°), bases extend slightly beyond front of notothyrial platform, distal terminations rounded; socket margins undifferentiated. Myophragm low, through posterior third of shell floor. Anterior adductor scars extend to about midlength of shell floor, about one-third longer than posterior scars. Mantle canal system and pattern of tubercles not preserved. Interior bears imprint of radial ornament around anterolateral margin, rarely thickened.

Ventral interior as described for the genus; muscle field maximum length ~25% of shell length (average of 6 valves), slightly wider than long. Mantle canal system variably impressed, saccate; main trunks of *vascula media* arise at anterior edges of diductor scars, initially divergent, to bifurcation into medially directed anterior trunks and laterally directed lateral trunks that enclose large, closely spaced *vascula myaria*. Tubercles marking pseudopunctae in a row parallel to anterior margin of lateral trunks and widely scattered through anterolateral shell margin. Anterolateral margin, rarely thickened, preserves imprint of radial ornament.

Discussion. — The larger specimens of this species are encrusted by overgrowths of co-

Measurements.

Specimens on Figure 3:

Grid location	Length (mm)		Width (mm)	Interarea length (mm)		Comae
	ventral	dorsal		ventral	dorsal	
23 28	13	-	17	-	-	+
63 23	10	-	18 (20)	-	-	?
78 43	-	11	18	-	-	+
23 16	-	11	13 (16)	-	-	?
60 40	11	-	16	-	-	?
50 50	-	11	15	-	-	+
38 21	-	11	15	-	-	+
42 50	10	-	13 (15)	-	-	?
72 36	9	-	16	-	-	+
19 24	11	9	13	2	.5	+
61 45	-	10	13	-	-	+
60 34	-	10	12	2	.75	+
28 19	-	9	12	1.5	.75	+
86 37	9	-	9 (12)	-	-	+
40 22	9	-	11	-	-	-&+
59 51	8	-	10 (12)	-	-	-&+
36 43	-	8	7 (12)	-	-	+
45 39	-	8	10	-	-	+
69 41	-	7	8 (10)	-	-	+
56 29	-	7	7 (9)	-	-	?
51 12	6	-	9	-	-	-
05 25	6	-	9	-	-	?
74 47	6	5	4 (8)	-	-	-
27 14	-	5	7 (8)	-	-	-

Holotype and individually measured paratypes:

Specimen number	Length (mm)		Width (mm)	Thickness	Interarea length (mm)						Comae +present -absent	
	ventral	dorsal			ventral	dorsal						
116659	8.5	8.0	14.5	3.8	2	1					+	
	Ventral muscle field											
							length	(mm)	width			
(holotype)								di(ea)	add	t		
116658	15	13	15	5	-	-	3	1	2	4	+	
116660	11	-	17	3	-	-	3	1	2	4	+	
116661	9	-	11	3	-	-	2.5	?	2	?	?	
116662	12(15)	-	10(14)	2	2	-	3	5	2	3	+	
116665	13	-	13	1	2	-	?	?	?	?	+	
116668*	10	-	11	2	1.5	-	?	?	?	?	+	
116666	9	-	16	2	1.5	-	2.5	undif.		3	+	
116667	7	-	12	1	1	-	1.5	undif.		3	+	
116669*	6	-	10	?	?	-	?	?	?	?	-	
116670	5	-	8	1	?	-	1	.5	1	2	?	
	Notothyrial platform											
							length	width				
									length	width		
116663			10	12(13)	1		1	1.5	4	4	?	
116664			10	8(10)	1		1	1	3.5	3	?	

* - distorted (narrowed) by cleavage.

mae, considered to be products of shell secretion during adult stages of growth (Williams 1962, p. 176). The partial development of comae around the anterolateral margins of some smaller specimens is more readily explained by this process than the complete encrustation (except at the palintrope) of larger ones, particularly the one specimen (Fig. 3, coords. 61 45), a dorsal, whose anterolateral edge is not encrusted.

Family LEPTELLINIDAE Ulrich & Cooper, 1936
Subfamily LEPTELLININAE Ulrich & Cooper, 1936

Genus *BOCKELIA* new genus

Diagnosis: — Thin-bodied, concavo-convex, unequally costellate shells, wider than long, pseudodeltidium present, notothyrium probably open: interiors have medially reentrant, undercut subperipheral rims in both valves; dorsal valve with orthoid cardinalia, ventral muscle field short, wider than long.

Derivation of the name. — For Dr. Johan Fredrik Bockelie.

Type species, and only species assigned. — *Bockelia angusticostata* new species herein.

Description. — Medium size, thin-bodied, wi-

der than long; cardinal extremities acute to auriculate; outline semi-elliptical, sides and front broadly rounded, dorsal valve shallowly concave; broad dorsal sulcus and ventral fold posteriorly confined, flattening anteriorly before reaching rectimarginate anterior commissure. Ventral interarea slightly concave, apsac-line, dorsal interarea anacline, pseudodeltidium present, moderately arched at the sides, medially carinate; notothyrium bordered by chilidial plated. Radial ornament of unequal costellae, unusually coarse for plectambonitaceans.

Dorsal interior has low, short, convex notothyrial platform of thickened shell, lacking defining anterior margin; cardinal process simple, brachiophores widely divergent, short. Median ridge low posteriorly, increasing in width and height anteriorly; terminating at elevated junction with subperipheral rim. Subperipheral rim bilobed, parallel to anterolateral shell margins, medially reentrant and undercut at the front. Mantle canal system not known.

Ventral interior has short teeth supported by short dental plates that form the sides of short, wide muscle field. Muscle field slightly thickened, with broadly arcuate anterior termination; adductor scars wide, about equal in length to diductor scars. A pair of low, sub-

parallel depressions extends forward from margin of muscle field to subperipheral rim; subperipheral rim present except in medial sector between these depressions. Mantle canal system not known.

Discussion. — Genera comparable to this monotypic genus are the leptellinid *Tourmakeadia* Williams & Curry 1985 and the leptestiid *Anoptambonites* Williams 1962. The delthyrium of both is open whereas that of *Bockelia* is covered by a pseudodeltidium. The more distant relationship with *Anoptambonites* is shown by their contrasting cardinalia, especially their cardinal processes; that of *Bockelia* is a simple ridge, unlike the trifid structure of *Anoptambonites*. The simple cardinal process of *Tourmakeadia* is similar to that of *Bockelia* but the notothyrial platform of the two genera are different; that of *Tourmakeadia* is longer than that of *Bockelia* and is concave with a raised anterior margin whereas in *Bockelia* it is flat to convex and its anterior margin is poorly defined. Both *Tourmakeadia* and *Bockelia* are based on single species represented by small suites of samples, each from a single locality. Those of *T. fimbriata* Williams & Curry 1985 from the Tourmakeady Limestone. Co. Mayo, Ireland (about 12 specimens) are silicified, largely fragmentary, and small, but structural strain is not apparent from illustrations (Williams & Curry 1985, figs. 176–182). *Bockelia angusticostata* n. sp. (see below) is represented by more than 40 specimens preserved as internal and/or external molds that are manifestly strained and about twice the size of the Irish species. Assignment of these species to different genera may be influenced by these differences in size and preservation, but the consistent presence of a pseudodeltidium in *B. angusticostata* is shown by its presence in all of the six specimens preserving the ventral palintrope (see Fig. 9N).

Bockelia angusticostata n. sp.

Figure 9, A-N.

Derivation of the name. — Latin *angustus* (=narrow) + *costae*.

Diagnosis. — Medium-size shells, hinge-width one-third to one-half greater than length; ornament unequally parvicostellate, costellae narrower than interspaces; stronger costellae spaced at about 1 mm intervals at shell front, separated by 1 to 4 weaker ones that arise at and beyond midlength; interspaces marked by closely spaced growth lines.

Material. — Holotype, dorsal valve (PMO 116671), 5 figured and measured paratypes (PMO 116672 – 116676), 2 unfigured measured paratypes, 33 paratypes neither measured nor figured.

Description. — Semi-elliptical in outline, hinge-width (W [8 specimens] 18 (>14, <19)) more than one-third (44%) greater than length (L >8, <11); cardinal extremities acutely angular (60°–75°), a small posterolateral segment of the sides concave. Ventral interarea about three times longer than dorsal interarea; ventral beak low, dorsal beak slightly depressed. Maximum thickness at midlength, 15–20% of shell width (i.e. 1.5–2 mm in specimens about 10 mm wide). Dorsal sulcus, more conspicuous than ventral fold, variable in width, sides subtend 20°–45°, include 4 to 5 stronger costellae, deepest at midlength, extinguished at about 4/5th shell length; anterior margin rectimarginate.

Notothyrial platform short (~1 mm in large valves), anterior margin poorly defined; cardinal process simple, rises and thickens posteriorly; brachiophores short, diverge at ~130°. Lobes of subperipheral rim 1.5–2.0 mm inside posterolateral shell margin from hingeline, divided anteriorly by sharply curved medial reentrant about 44 mm inside shell margin. Dorsal median ridge increases in height and width from barely discernible origin in front of notothyrial platform to maximum width at medial reentrant of rim.

Dental plates short, poorly preserved, bases widely divergent, forming sides of muscle field. Arcuate anterior margin of muscle field of slightly thickened shell; muscle field short and wide about one-sixth shell length, three times wider than long; adductor scars slightly longer than diductors. Shell floor has pair of narrowly divergent shallow depressions that extend from margins of diductor scars to submedial terminations of subperipheral rims. Ventral subperipheral rims similar to those of dorsal valve but less sharply defined, interrupted in anteromedial sector, and terminated against outer sides of submedial depressions.

Discussion. — The description of this species and the genus established to contain it is a composite based on the better preserved parts of specimens of the type lot. Despite the obliteration of some details and the deformation of some original proportions, the observable features are those that are distinctive for the genus.

Measurements. — The holotype and figured and measured paratypes have the following dimensions:

Specimen number PMO	Length (mm)	Width (mm)	Interarea (mm)		Notothyrial platform (mm)		Subperipheral platform length (mm)		
			dorsal	ventral	length	width	max	median	hingewidth
Articulated valves									
116676	11	18	.7	2					
116677	9	15	.7	2					
Dorsal valves									
*116671	10	17	.5		1	1.5	8	6	13
116678	9	17	-		-	-	6	5	13
Ventral valves									
								Muscle field (mm)	
								length	width
116672	8	14	-	-	1	2		5	11
116673	9	16 (19)	-	1	1.5	3		5	15
116674	9	18 (19)	-	1	1.5	3		6	14
116675	10	16	-	2	2	4		6	12

* holotype

Genus *Vehnia* new genus.

Diagnosis. — Deeply concavo-convex, multico-stellate, cardinal process miniscule or lacking, socket ridges widely divergent, disc bears submedian, narrowly divergent septa; platform margin elevated, medially extended between anterior prolongation of septa; teeth wide, dental plates lacking, muscle field subequally trilobed, diductor scars longer than adductors.

Derivation of the name. — From Vehn farm (older spelling, now written 'Ven'), Korsvegen community.

Type species, and only species assigned. — *Vehnia triangularis* (Reed 1932).

Description. — Small shells, triangular in outline, concavo-convex in profile, with costellate ornament. Interareas coplanar, dorsal hypercline, about half the length of apsacline ventral interarea. Imperforate pseudodeltidium and chilidial plates present. Shell surface finely costellate. Shell structure not determined, presumably pseudopunctate.

Dorsal interior has short, shallow notothyrial cavity; presence of cardinal process variable, socket ridges widely divergent. Platform bearing pair of narrowly divergent submedian septa occupies posteromedial part of valve, defined by undercut rim at the sides and front, medially extended between prolongation of septa. Vascular system unknown.

Ventral interior has short, broad teeth; dental plates lacking. Muscle field subequally trilobed, diductor scars longer than adductors. Shell floor with broad median ridge between shallow, medially elongate depressions. Vascular system unknown.

Discussion. — This monotypic genus is established to accommodate the species '*Chonetoidea triangularis*' Reed (1932) that was described in the absence of knowledge of its internal features. Its leptelline rather than sowerbyellid affinities are indicated in its dorsal valve by the inconsistent presence of a cardinal process, and the widely divergent socket ridges. It is probably closely related to *Petroria* Wilson 1926 (see also Cooper 1956 and Ross & James 1987) but the configuration of the platforms in the two genera are notably different: in *Petroria* it is slightly reentrant anteromedially, and it bears a median ridge that extends beyond its anterior margin, whereas in *Vehnia* the platform is anteromedially prolonged and medially depressed between the pair of submedian septa.

Vehnia triangularis (Reed, 1932)

Figure 5, A-T.

□ *Leptaena?* n. sp. Brøgger, 1877, pl. 2, figs. 8-9.

□ *Chonetoidea triangularis* Reed 1932, p. 137, pl. 20, figs. 8-11.

Diagnosis. — Interior as specified for the genus, herein; exterior as described by Reed (1932), except: (a) ventral beak erect, not projecting beyond the plane of the interarea, and (b) medial 'radial line' of dorsal valve stronger than that of the ventral valve.

Material. — Lectotype: articulated valves, PMO 33034, Pl. 20, fig. 10 of Reed, 1932; specimen fully exposes dorsal external surface and a small anterior part of the ventral exterior. Paralectotypes: ventral valve, external surface, PMO 33032, Pl. 20, fig. 8 of Reed 1932 (only this specimen of all those examined for this study bears a narrow, shallow sulcus that includes a pair of submedian costae separated by a median interspace); external mold of dorsal valve and conjoined interareas, PMO 33033, Pl. 20, fig. 9 of Reed, 1932. Locality for these given as: 'Locality 2. Katuglåsen, HølonDET' (Reed, 1932, p. 116).

The following description and remarks are based primarily on specimens selected from about 200 obtained from samples collected by Neuman and Bruton in 1970 from near Damtjern (Locality 1 of this paper), supplemented by about 50 specimens from Locality 5, both from a siltstone unit of the HølonDA Limestone. For other occurrences see Table 2.

Description. — Small shells, triangular in outline, hinge width (w [17 specimens] 4.4 (3.0, 5.4)) greater (29%) than length of longest (ventral) valve (Lv [15 valves] 3.4 (2.2, 4.5)); dorsal valve length (Ld [13 valves] 2.3 (1.6, 2.9)), about one-third less than ventral valve. Cardinal extremities acute (~60°), sides converge to narrowly rounded, nasute anterior margin, profile deeply concavo-convex. Dorsal interarea short (Lid [9 valves] 0.24 (0.1, 0.4), about half (57%) as long as ventral interarea (Liv [10 valves] 0.44 (0.4, 0.5)). Pseudodeltidium highly arched, lacks foramen; chilidial plates present, possibly joined posteriorly. Concavity of dorsal valve shallow from umbo to midlength, increasingly concave beyond; anterior third normal to commissural plane. Ventral umbo swollen, valve medially arched at midlength, merging to uniform convexity, the anterior third of shell about 90° to posterior third in lateral view; anterior commissure rectimarginate. Radial ornament of low rounded costellae, arising in 2 or 3 indistinct zones of branching, about 10 per millimeter at anterior midwidth; single median costa, about twice normal height and width, extends from beak to anterior

margin of both valves. No concentric ornament observed.

Dorsal interior has short, shallow notothyrial cavity, cardinal process generally lacking (4 of 6 specimens), where present (on 2 of 6 specimens), tiny, knoblike, confined to posterior fifth of cavity. Socket ridges arcuate, initially diverging at ~45° from centerline at the side the notothyrium, curved to parallel posterior margin before merging with it about midway between centerline and posterolateral corner; total span of distal edges of socket ridges about half hinge-width. Platform occupies posteromedial half of valve floor, bears pair of submedian ridges that diverge at ~5° bordering thickened shell; platform outlined at sides and front by undercut rim; anteromedial sector of rim corresponds with steepening of dorsal curvature. Posterior terminations of rim joins inner face of palintrope at acute angles about midway between distal termination of socket ridges and shell corners; posterolateral margins converge at small angles (~20° to midline) for about half platform length to inward turn (~50°) at about midlength, joining anterior ends of septa forming short, raised medial trough. Adductor muscle scars variably impressed, undifferentiated; where present, occupy about half platform area. Vascular system not preserved; shell surface smooth.

Ventral interior has short, broad teeth, lacks dental plates, diductor muscle scars each about equal in width (~0.5 mm) and longer (~1.2 mm) than adductors (~0.5 mm wide, 1.0 mm long). Broad median ridge near midlength separates pair of shallow longitudinally elongate elliptical pits.

Discussion. — The uniform costellation of this species together with the pronounced median costa on each valve of most specimens are distinctive of this species, as are the internal features that characterize the monotypic genus erected to contain it, especially those of the dorsal valve.

Most of the specimens examined for this study are widely scattered through calcareous siltstone where they are by far the most abundant fossils. A few occur in centimeter-thick concentrations of shelly material, largely disarticulated pelmatozoan ossicles. Articulated valves, incompletely filled with sediment, are far more common than disarticulated valves, suggesting that live adults were buried by sediment and were moved very little after death.

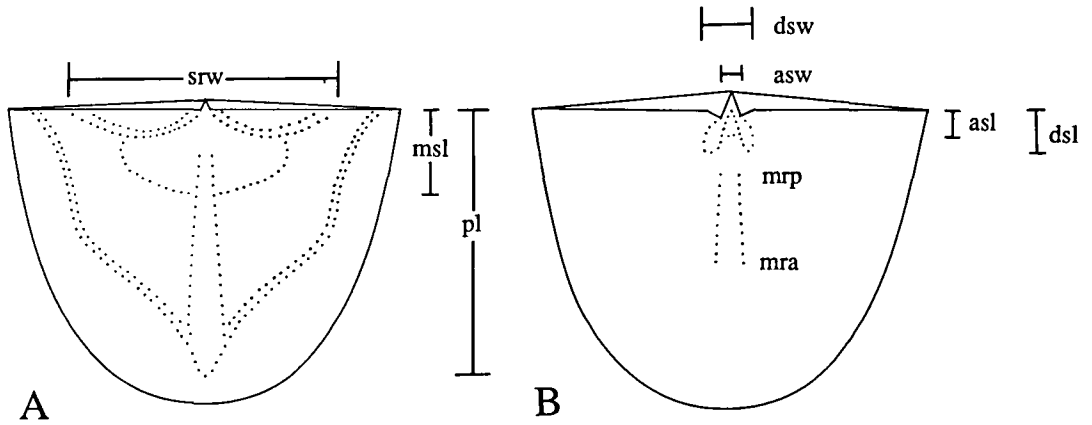


Fig. 4. Diagrams of interiors of *Vehnia triangularis* (Reed), showing location of measured features. A - dorsal valve, B - ventral valve. Average width is 4.4 mm. Abbreviations: A, dorsal valve - msl = muscle scar length, pl = platform length, srw = socket ridge width; B, ventral valve - asl = adductor scar length, asw = adductor scar width, dsl = diductor scar length, dsw = diductor scar width, mra = anterior termination of median ridge, mrp = posterior termination of median ridge.

Measurements. — See diagram (Fig. 4) for features measured.

Specimen no.	Length (mm)		Width (mm)	Thickness (mm)	Costellae (no per. mm)	Interareas (mm)		muscle scar length (mm)	platform length (mm)	sock. ridge width (mm)	median ridge shell length, post.-ant. (mm)
	dorsal	ventral				dorsal	ventral				
PMO											
*33034	3.2	3.75	5.0	-	10						
+33033	3.9	4.5	4.9(5.4)	-	9						
+33032	-	2.4	4.3	-	14						
116679	3.2	3.6	3.9	1.8(v)	11	.2	.4				
116683	1.6	2.2	2.6(3.0)	0.8(d)	-	.1	.5				
116681	2.5	2.9	4.6	1.3(d)	10	.2	.5				
116682	2.9	3.6	5.2	2.1(d)	10	.3	.4				
116680	2.8	3.2	4.8	0.5(d)	9	.4	.5				
116684	2.8	3.6	4.6	1.8(d)	11	.3	.5				
116685	3.5	3.8	3.7(4.0)	2.1(d)	-	.3	.4				
116686	3.5	4.2	4.2	-	9	.2	.4				
116687	2.7	2.9	3.6	0.8(d)	9	.2	.4				
Dorsal valves											
116688	2.5	-	4.3	1.0	11	1.1	2.2	1.9			
116689	3.6	-	5.0	1.2	12	1.16	2.4	1.7			
Ventral valves						musclescars					
						adductors		diductors			
						length (mm)	width (mm)	length (mm)	width (mm)		
116690	-	4.1	4.2	1.8	1.0	0.4	1.3	0.5	1.8-2.8		
116691	-	3.7	4.0	-	1.0	0.7	1.2	0.4	1.3-2.0		
116692	-	3.4	5.4	1.4	1.0	0.4	1.2	0.6	1.3-2.0		

*-lectotype

+Paralectotype

Subfamily ISOPHRAGMATINAE Cooper, 1956
Genus *SYNDIELASMA* Cooper, 1956

Syndielasma katuglasensis (Reed), 1932

□ *Stropheodonta katuglasensis* Reed, 1932, p. 136, Pl. 21, figs. 1-6, ?fig. 13

□ *Holtedahlina? hirundo* Reed, 1932, p. 138, Pl. 22, figs. 2-8

□ *Syndielasma* cf. *S. biseptatum* Cooper, 1956: Neuman in Neuman & Bruton 1974, p. 91, fig. 11, A-Q.

Discussion. — The name *Syndielasma katuglasensis* is here used for specimens from the Hølonða Limestone previously assigned to this genus and to *Stropheodonta* and *Holtedahlina?* Those Reed assigned to *Stropheodonta katuglasensis* are conspecific with those he named *Holtedahlina? hirundo*. The features of the ventral valve illustrated by Reed (1932, Pl. 21, fig. 6), interpreted as canals through its interarea as in *Eochonetes* (Neuman in Neuman & Bruton 1974), are actually cracks in that specimen. The density of costellae is the principle difference between *S. katuglasensis* and *S. biseptatum*, the former having 15 to 20 costellae per 5 mm (Neuman in Neuman and Bruton, 1974, p. 93) compared to the average of 11 per 5 mm of *S. biseptatum* Cooper 1956, p. 743).

Order PENTAMERIDA Schuchert & Cooper, 1931

Suborder SYNTROPHIDINA Ulrich & Cooper, 1936

Family SYNTROPHOPSIDAE Ulrich & Cooper, 1936

Genus *RHABDOSTROPHIA* new genus.

Diagnosis. — Finely costellate; cardinalia of anteriorly elevated notothyrial platform bearing low cardinal process, bordered by dorsally convergent brachiophore plates; ventral valve with erect dental plates and thickened muscle field.

Derivation of the name. — From Greek *rhabdotos*= striped + *trophis*= swollen. Type species, and only species assigned. — *Rhabdostrophia striatisculpta* new species herein.

Description. — Medium-size, thick-bodied, uniplicate, costellate shells, transversely elliptical outline. Interareas short, concave, dorsal apsacline, length less than half that of anacline ventral interarea, notothyrium and delthyrium open, unmodified. Cardinal extremities obtusely angular; maximum width, near midlength, sides narrowly rounded, front broadly rounded. Lateral profile highly arched, beaks erect,

maximum convexity near midlength. Fold and sulcus developed at about midlength; anterior commissure broadly plicate. Radial ornament ramicostellate; concentric ornament subdued.

Dorsal interior has short, sharply pointed brachiophores supported by dorsomedially convergent plates that meet at shell floor, forming sides and floor of diamond-shaped notothyrial platform; cardinal process variably developed, where present, a low ridge that extends full length of notothyrial platform. Myophragm short, set between weakly impressed quadripartite adductor muscle scars. Mantle canal system not preserved.

Ventral interior has short, stout teeth, dental plates receding, erect, their bases forming the posterolateral half of the ventral muscle field; muscle field with thickened anterolateral margins, adductor scars longer than diductors. Mantle canal system not preserved.

Discussion. This monotypic genus is similar to two monotypic ramicostellate syntrophidine genera, the clarkellid *Thaumatrophia* Wang, 1955 and the syntrophopsid *Hesperotrophia* Ulrich & Cooper, 1936. The former, recorded only from the type locality of its type species, Lower Ordovician rocks in Liaoning Province, northeastern China, has a spondylium in its ventral valve; the latter, from the «upper Canadian Sarbach Formation, Fossil Mountain, Alberta, Canada» (Ulrich & Cooper, 1938) (now known as the Outram Formation of Arenig age (Norford, 1969)), is more closely related to *Rhabdostrophia*, but they differ in the configuration of their brachiophore bases, those of *Hesperotrophia* lying parallel to each other, while those of *Rhabdostrophia* converge and join medially. The limited development, occurrence, and distribution of these costellate syntrophodies suggests that this ornament arose independently at widely separated locations, but nowhere gave rise to large populations or persistent stocks.

Rhabdostrophia striatisculpta new species.
Figure 7, G-R.

Diagnosis: — Transversely elliptical *Rhabdostrophia* with fine ramicostellate ornament, 5 to 6 costellae per millimeter over entire shell surface.
Derivation of the name. — Latin, *stria* (line) + *sculptilis* (carved).

Material. — Holotype, dorsal valve, PMO 116693, 4 figured and measured paratypes, PMO 116694–116697, 5 measured paratypes,

Measurements.—

Specimen no. PMO	Length (mm)	Width (mm)		Thickness (mm)	Interarea length (mm)		Muscle field (mm)	
		hinge	maximum		dorsal	ventral		
Dorsal valves								
Holotype								
116693	9	-	10	-	-	-		
Paratypes								
116698	13	13	19	-	-	-		
116699	5	5	8	-	-	-		
Ventral valves								
							length	width
116696	11	10	16				4.0	2.5
116697	9	9	14				3.0	2.0
Articulated valves								
116694	13	10	15	9	.5	2		
116695	12	11	15	9	1	2		
116700	7	7	11	5	.7	1.5		
116701	9	8	11	-	-	-		
116702	10	9	12	7	.7	1.5		

and 5 paratypes neither measured nor figured, all from Hølonða Limestone at Østlund.

Description. — Transversely elliptical in outline, cardinal angles obtusely angular, maximum width near midlength, about one-third greater than hinge-width (L [10 specimens] 10 (5, <13); HW[10 specimens] (8m <19)); anterior margin broadly rounded except where medially extended in sector of fold and sulcus on largest specimens. Initiation of folding of shell variable, ventral sulcus originates in posterior quarter to midlength of ventral valve, dorsal fold and ventral sulcus well developed beyond midlength of adult shell, sides diverge at about 30°, to uniplicate anterior margin. Ventral interarea length of large specimens, (1.5-2.0 mm) about twice that of dorsal valves (0.5 to 1.0 mm). Radial ornament uniformly ramicostellate, 5 or 6 costellae per millimeter over entire shell surface; branching pattern indistinct; costellae impressed on shell interior; concentric ornament, where present, one or two growth lines around the anterolateral margins of large shells.

Dorsal interior known from two adult shells (PMO 11693 [Fig. 7A-B], PMO 116698) and one immature specimen half their size (PMO 116699). Notothyrial platform wider than long (in adult specimens, length, 1.5 mm: width ~ 2 mm); fulcral plates lacking, socket indistinct. Cardinal process present in large specimens, blade-like, extending full length of notothyrial platform: myophragm very short. Cardinal process and myophragm lacking in small specimens. Mantle canal system not preserved.

Ventral interior, known from 2 specimens (PMO 116696 [Fig. 7, K,L.], PMO 116697 [Fig.

7M] has short, stout teeth somewhat hooked posteriorly; muscle field medially elongate, about one-third longer than wide,; adductor scars longer and about twice the width of diductor scars. Mantle canal system not preserved.

Discussion. — Features that characterize *R. striatisculpta* and the genus based on it are its distinctive combination of internal structures and its ramicostellate ornament. The folding of the valves and the strength of costellae are reasonably consistent among the specimens of the suite under study, and are probably the features to be compared at the specific level should congeners be discovered.

Genus *RHYSOSTROPHIA* Ulrich & Cooper, 1936.

Rhysostrophia vagans (Reed)

Figure 6, A-G

□ *Oxoplecia vagans* Reed, 1932, p. 135, Pl. 20, figs. 4, 4a.

□ *Oxoplecia dorsata* (Hisinger) of Reed, 1932, p. 134, Pl. 21, figs. 8, 9, 9a, 14, 15, 16.

Diagnosis. — Moderate-size, transversely elliptical, dorsibiconvex, variably coarse-ribbed shells having a pronounced dorsal fold and ventral sulcus; brachiophores lacking supporting plates; spondylium supported by short median septum.

Material. — Holotype, PMO 32958, from «Loose boulder of nodular limestone rich in shale, Vestre Katuglås.» (Reed, 1932, p. 117). Illustrated specimens, 3 articulated valves (PMO 116703 [Fig. 6 A-C], PMO 116704 [Fig. 6F], PMO 116705 [Fig. 6G] from Hølonða Limestone, Locality 2; ventral internal mold (PMO

116706 [Fig. 6 D-E] from Locality 5, See Table 2 for occurrence at other localities.

Description. — Small to medium-size shells, transversely elliptical in outline, dorsal fold and ventral sulcus most pronounced in larger specimens. Maximum shell width near midlength, about one-third greater than length and hinge-width; lateral profile thickens with increasing shell size. Summary of measurements of 9 specimens, excluding the holotype: L=10 (4, <13); HW=11 (5, <12); MW=14 (7, <18), T=6 (3, <11); for dimensions of holotype, see table of measurements. Cardinal extremities obtusely angular to rounded, sides broadly rounded, fronts of smaller specimens (length >7mm) broadly rounded, those of large specimens extended in median sector corresponding with fold and sulcus. Fold and sulcus originate near beak, sides diverge at 20°-30°, forming uniplicate anterior margins. Lateral profile changes with increased size; small specimens lenticular, maximum thickness at midlength less than shell length; large specimens tumid, thickness nearly equal to shell length. Interareas short, concave; dorsal orthocline, about half the length of apsacline ventral interarea; notothyrium and delthyrium open, unmodified. Radial ornament costate, costae and interspaces sharply rounded plications of shell, most arise near beak and extend with increasing dimensions anteriorly, but a few costae arise by branching and by implantation at various points in the middle third of the shell. Number of costae variable; fold bears 4 to 7 larger ones (plus 1 or 2 minor branches), commonly with relatively wide median interspace that corresponds with median costa in sulcus, costae on flanks number 9 to 14. Concentric ornament of very fine fila.

Dorsal interior, known from one small imperfectly preserved specimen (PMO 116720, not illustrated: Locality 1, Damtjern), has deep notothyrial cavity bounded by elongate, dorsally convergent brachiophore terminations not preserved, fulcral plates absent, cardinal process lacking.

Ventral interior, known from two specimens, one well preserved (PMO 116706, Locality 5, Katugleås, Fig. 6, D-E), the other much less so (PMO 116721, locality 4, Fjøsåsen, not illustrated), has stout teeth and an anteriorly elongate, posteriorly sessile spondylium, anteriorly supported by a short, stout median septum.

Discussion. — Reed (1932) identified two species of '*Oxoplecia*' in the Hølonða Limestone,

but he provided no information on the interiors of either of them, and a syntrophid genus of this kind had not yet been described. The few interiors of such brachiopods in the present collections are consistently those of *Rhysostrophia*, and no brachiopod from the Hølonða Limestone has tripleciid interiors. Reed named '*Oxoplecia vagans*' from a single specimen, and he questionably assigned another to it; his description of that species dwelled upon the branching pattern and irregularity of the ribs on the fold, but his total count of 6 ribs here and 9 to 10 on the shell flanks («lateral lobe») are the same as those of his other species, '*Oxoplecia dorsata* (Hisinger)', documented by drawings of five specimens. Reexamination of Reed's specimens in the light of specimens examined for this study suggest that they are conspecific within a highly variable species for which the name *R. vagans* is apt. The holotype of *R. vagans* (PMO 32958) is slightly larger than those he classed as '*Oxoplecia dorsata*' and the other specimens of *Rhysostrophia* examined for this study; the specimen Reed questionably referred to *R. vagans* cannot be located.

Diagnosis of species of *Rhysostrophia* is complicated by their variability. As Ross (1970) noted in his discussion of *R. nevadensis* Ulrich and Cooper, most individuals are not bilaterally symmetrical, and no two specimens in the same population have the same number of costae. Nevertheless, after examination of suites of specimens of North American species housed in the U.S. National Museum of Natural history, I conclude that *R. vagans* is distinguished by the smaller number of its costae compared to specimens of comparable size that have been assigned to North American species of the genus, and to species from northeastern U.S.S.R. (Ordovskaya in Chugaeva et al. 1973) and northwestern Ireland (Williams 1972).

Family CAMERELLIDAE Hall & Clarke, 1894
Subfamily CAMERELLINAE Hall & Clarke, 1894
Genus *IDIOSTROPHIA* Ulrich & Cooper, 1936

Idiostrophia sp.

Figure 9, O-P.

□ *Parastrophina* cf. *angulosa* (Törnquist), Reed, 1932, p. 141, Pl. 21, fig. 11.

□ ?*Parastrophina hemiplicata* (Hall)var., Reed, 1932, p. 140, Pl. 21, figs. 7, 7a.

Measurements. —

Specimen no., PMO	Length (mm)	Width hinge	(mm) maximum	Thickness (mm)	Interarea dorsal	length ventral	Costae no. sulcus	fold	flanks
Holotype 32958	14	10(20)	23	12	.5	2	5	6	14
Illustrated specimens									
116703	13	9(12)	15(18)	11	.5	1	5	4+(2)	12
116704	13	9(12)	17	10	.5	1.5	-	6+(1)	10
116705	10	12	13	5	.5	1.5	1	4	9
116706	10	12	16	4	-	-	4	-	13
Not illustrated — all locality 4									
116707	9	8	11	3	.5	1	3	-	8
116708	4	5	7	3	-	-	-	4	7
116709	12	10	16	5	-	-	5	-	13-14
116710	7	9	11	4	-	-	-	5	12
116711	11	12	17	10	.5	1.5	6	7	9

Description. — Five articulated specimens in the present collections and two of Reed's specimens are assigned to an unnamed species of this genus. In the present collections, four are considered to be mature individuals, one from Locality 1, and three from Locality 12 which also yielded one juvenile. Specimens of mature individuals have the following characteristics; triangular in outline, interareas obscurely preserved, presumably small; maximum width slightly greater than length, near the front. Thickness of articulated shells almost (80%) as great as length, the convexity of opposite valves about equal. Dorsal and ventral surfaces lack radial ornament posteriorly, but costae arise at about 1/4 shell length, and by midlength number the 10 to 12 that persist to the anterior margin. Characteristic of most species of the genus, the posterolateral sides are well defined, steep, and join the lateral commissure at about 90° — a feature called 'lunulelike' by Ross (1972, p. 23). Anterior commissure rectimarginate, with zig-zag pattern derived from opposed coaste and interspaces. The immature specimen, about 5 mm long, 4 mm wide, and 3 mm thick, is bell-shaped in outline; its posterior margin is relatively more blunt than that of the mature specimens, corresponding with the preservation of interareas on this specimen; the orthocline ventral interarea has a wide, open delthyrium that overhangs and obscures the tiny dorsal interarea. The steep-sided lateral slopes that begin at the posterolateral corners of this shell suggest that this specimen is a juvenile

Idiostrophia.

Discussion. — These specimens are not assigned to a species because they are too few and too poorly preserved to compare with established species. They closely resemble *Idiostrophia* n. sp. A of Ross (1972, p. 24, Pl. 4, figs. 9-13) in proportions and they lack the dorsal median groove on most species (Ulrich and Cooper, 1938, pl. 56, C and D; Ross 1972). Ross's species, whose complex nomenclatural history he explained (Ross, idem.) came from the 'Asaphus' Shale, Stage 3cβ, Tøyen district, Oslo. Both valves of the partly exfoliated specimen described and illustrated by Reed as *Parastrophina* cf. *angulata* (Törnquist) have a median septum, as is characteristic of *Idiostrophia*; septa to confirm its assignment to this genus are not visible on the smaller specimen that Reed identified as *P. hemiplicata* (Hall).

Measurements. —

Specimen no. PMO	Length (mm)	Width (mm)	Thickness (mm)	Costae (no.)	Apical angle
116712	11	13	8	12	100°
116713	10	11	8	10	90°
116714	5	4	3	0	60°
32938 ^{1/}	7.5	8	6	9	80°
32988 ^{2/}	5	5	3	8	90°

^{1/} Reed 1932, Pl.21, fig. 11 as *Parastrophina* cf. *angulose* Törnquist

^{2/} idem, fig. 7 as *Parastrophina hemiplicata* (Hall) var.

Subfamily STENOCAMARINAE Cooper, 1956
Genus *STENOCAMARA* Cooper, 1956

Stenocamara norvegica (Reed), 1932
Figure 9, S,T,U.

□ *Pentamerus* sp., Brøgger, 1877, p. 18, pl.1, figs. 10 a, b.

□ *Triplecia norvegica* Reed, 1932, p. 132-133., pl. 21, figs. 12 a-c.

Description and discussion. — This species was established for a single specimen (PMO 33039) collected by Brøgger from Katugleåsen more than 100 years ago. Later collections from the vicinity of Katugleåsen yielded no additional specimens, but deformed and partial internal molds of two dorsal valves and two ventral valves from the Nyplassen Formation at Locality A (Bjørnlivvatnet) have internal features of this genus, and they are assigned to this species: in the dorsal valve a cruralium supported by a median septum, and in the ventral valve subparallel dental plates.

The type specimen of *S. norvegica* is about one-third larger than *S. perplexa* Cooper, 1956, but the two have similar outlines, profiles, and length/width proportions. The fold and sulcus of both are similarly steep-sided, and in both the crest of the fold bears a shallow depression, matched by a corresponding ridge in the trough of the sulcus. Reed's illustration shows a radial ornament of fine costellae and a concentric ornament of widely spaced growth lines: most of the surface of that shell, however, is exfoliated, and little of its original surface is preserved. The ornamentation of Cooper's specimens is variable, probably due to differences in their preservation. Some, including the type of *S. perplexa*, are smooth, as is specified in his diagnosis of the genus: some that are slightly weathered or exfoliated have fine radial lines that are probably reflections of shell fibers, and a few appear to bear fine costellae but these lack concentric ornament. The larger size and the presence of concentric ornament of *S. norvegica* thus distinguishes it from *S. perplexa*.

Stenocamara is a common fossil only in the Skjølberg Limestone of Smøla, Norway (Harper 1981). These rocks are coeval with the Hølonde Limestone and both have similar paleogeographic settings (Bruton & Harper 1985). Elsewhere it is a rare component of contemporaneous and slightly younger assemblages. The two species in the American southern Appalachians are both from rocks that

are probably slightly younger (Cooper 1956, p. 603-604). Contemporaneous occurrences include the Table Head Formation, western Newfoundland, documented by a single specimen in the brachiopod collection of the U.S. National Museum of Natural History, collected by H.B. Whittington, and a small number of fragmentary silicified specimens from the Antelope Valley Limestone, southern Nevada that were questionably assigned to the genus by Ross (1967, p. D6. pl. 2, figs. 15-16).

Trilobita, by D.L.Bruton

Family NILEIDAE Angelin, 1854

Genus *NILEUS* Dalman, 1827

Type species: *Nileus armadillo* Dalman, 1827

Nileus sp. indet.

Figure 11, A-B

Material. — One incomplete cranidium with four thoracic segments, PMO 117609 from Locality 1, Damtjern, GR 572014.

Discussion. — The incomplete and badly damaged cranidium with parts of four attached thoracic segments (Fig. 11, A-B), is assigned to *Nileus* on account of the very broad (trans.) rachis and short pleurae. Strand (1948, p. 80) made a similar comment on material he had from the Hølonde Limestone at Trotland. The present specimen, from Damtjern, is the best preserved, but is insufficient to compare with numerous Whiterock species described from California, Nevada (Ross 1967, 1972), Maine (Whittington 1964), central Newfoundland (Dean 1971), western Newfoundland (Whittington 1963, 1965), and Spitsbergen (Fortey 1975).

Family REMOPLEURIDIDAE Hawle and Corda, 1847

Genus *BLOSYROPSIS* Whittington, 1965

Type species: *Blosyropsis billingsi* Whittington, 1965

Blosyropsis sp. cf. *B. billingsi* Whittington, 1965
Figure 11,F

Material. — One small cranidium, PMO 117623, from Locality B, Østlund, GR 473988.

Discussion. — The deep, diagonally-directed 1P pit, a smooth 2P area, a broad palpebral rim, and general glabellar shape are all features of the unusual remopleuridid genus *Blosyropsis* described by Whittington (1965, p. 377-80) from the middle Table Head Formation of western Newfoundland. The present speci-

men, preserved as an external mold that lacks the anterior glabellar tongue, is a young cranium comparable to that figured by Whittington (1965, pl. 42, figs. 5-6).

Family BATHYURIDAE Walcott, 1886

Genus *GONIOTELINA* Whittington & Ross, 1953

Type species: *Eleutherocentrus williamsi* Ross, 1951

Goniotelina broeggeri (Strand 1932)

Fig. 11, C-D

□ *Trilobites* n.sp. Brøgger, 1877, p. 17, pl. 1, figs. 1-7.

□ *Gonotelus broeggeri* Strand, 1932, p. 159, pl. 27, figs. 4-8, text-fig. 16.

□ *Gonotelus? broeggeri* Strand, 1948, p. 76-77.

□ *Acidiphorus broeggeri* (Strand); Whittington, 1968, p. 56.

□ *Goniotelina broeggeri* (Strand); Bruton, 1974, p. 104-107, fig. 15, C-L, fig. 16, A-D.

Material: The holotype pygidium (PMO 318439; Strand, 1932, pl. 27, fig. 6), and four pygidia (PMO 31836, 31841-2, 31847, 32235) from Katugleåsen, two pygidia (PMO 31824, 31827) from Ven, one pygidium from Hølonða collected by Brøgger in 1876, and material collected from Trotland farm including two pygidia (PMO 93468, 93471), two cranidia (PMO 93469 a-b), and one free cheek (PMO 93470).

Discussion. — Recent collecting from the type locality at Katugleåsen has provided fragmentary material of this species, known also from the Hølonða Limestone at Trotland and Ven (Bruton 1974). The two fragmentary pygidia (Fig. 11, C-D) are topotypes. In assigning this species to *Goniotelina*, Bruton (1974, p. 107) discussed the differences between that genus and *Acidiphorus*, noting that in the former the pleural area of the pygidium is relatively flat and not turned down laterally, and the pleural ribs and furrows are better defined. The pygidium of *Acidiphorus? ligo* Fortey (1980, p. 70, pl. 13, figs. 5-7) from Spitsbergen seems more like that of *Goniotelina* than *Acidiphorus*, but differs in that the terminal portion of the rachis and the spine are separated by a marked change in slope and are not continuous. This difference is slight, and features of the cranium are comparable with a form such as *G. hesperina* Ross (1967, pl. 6, figs. 10-15).

As noted by Bruton (1974, p. 104) and Fortey (1980, p. 68-72), the differences between

Acidiphorus and *Goniotelina* are slight, and intermediate forms indicate that they may be the same.

Family ILLAENIDAE Hawle & Corda, 1847

Genus *ILLAENUS* Dalman, 1827

Type species: *Illaenus crassicauda* (Wahlenburg, 1821)

Illaenus cf. *I. auriculatus* Ross, 1967

Figure 10, A-C, E-H, J-L.

Material. — One cranium (PMO 117614), 3 pygidia (PMO 117613, 117621-22) and 2 free cheeks (PMO 117616-17) from Locality 3, Damtjern, GR 574014, and 4 pygidia (PMO 32240, 32231, 117611-12) from Katugleåsen, GR 566008.

Discussion. — This species belongs with the *Illaenus sarsi* species group of Jaanusson (1957, p. 110), characterized by large posteriorly placed eyes and a pygidium with a cusped inner margin of the doublure.

Strand (1932) figured illaenid material from Katugleåsen, including a pygidium (Strand 1932, pl. 27, fig. 3) showing a terrace line pattern that curves convex forwards over the rachis and extends laterally over the pleural area. A similar pattern is shown on material collected from the same area by Brøgger in 1886, and more recently by the author (Fig. 10, H, J, K), together with other pygidia, a cranium (Fig. 10, A-C), and free cheeks (Fig. 10, F-G), from Damtjern along strike to the east. In dorsal and lateral views, the cranium resembles most closely silicified material of *I. auriculatus* Ross (1967, p. 16-17, pl. 5) from a Whiterock horizon in California and material of *I. cf. I. auriculatus* from the Meiklejohn bioherm, Nevada (Ross, 1972, p. 32, pl. 12, figs. 19-26, pl. 13, figs. 1-3). The free cheeks illustrated here also resemble those of the Whiterock material in having a broad, rounded lateral outline behind the notched margin, a lateral rim, and a series of parallel terrace lines extending from the anterior suture, but dying out laterally. Ross (1972, pl. 13, figs. 5-7, pl. 14, figs. 13-15), figured two kinds of associated pygidia that being more transverse with pronounced antero-lateral facets (Ross, 1972, pl. 13, figs. 5-7), being the more likely. This shape of pygidium resembles the present material which, in addition has an extended cusped inner edge of the doublure with small median notch (cf. Ross, 1967, pl. 5, figs. 31, 32, 40).

A small median notch is also present on

pygidia of *I. tumidifrons* Billings, 1865 figured by Whittington (1963, pl. 16, fig. 16) from Lower Head, western Newfoundland, and *I. fraternus* Billings, 1865 from the middle Table Head Formation, western Newfoundland (Whittington 1965, pl. 46, figs. 1-6, 8).

I. tumidifrons has a narrower glabella and pygidial rachis than does the present material, whilst *I. fraternus* has a similar free cheek, and small cranidia in lateral view have a similar profile (cf. Fig. 10, C and Whittington 1965, pl. 45, fig. 9). However, the terrace line pattern on pygidia and free cheeks is different in *I. fraternus*. Fortey (1980, p. 62) compared Whiterock material of *I. oscitatus* Fortey from Spitsbergen with all the above mentioned species, the differences between them being mainly in cranial proportions and surface sculpture. The present material is sufficiently well preserved to note that the dorsal exoskeleton of the cheek and pygidium do not have the same terrace line pattern and pitting as the material from Spitsbergen and Newfoundland, but is more like *I. auriculatus*.

Iliaenus sp. indet.

Figure 10, D, I.

Discussion. — Two additional pygidia (Fig. 10, D, I) are considered different enough from those assigned to *I. cf. lauriculatus* in being longer (sag.), with wider doublure and broad median notch. The specimen (Fig. 10, D) is slightly compressed laterally, but the second specimen is not. Both pygidia resemble the *Iliaenus* sp.d. of Ross (1972, pl. 14, figs. 13-15).

Family PLIOMERIDAE Raymond, 1913

Subfamily CYBELOPSINAE Fortey, 1979

Genus *ECTENONOTUS* Raymond, 1920

Type species: *Amphion westoni* Billings, 1865

Ectenonotus sp. indet.

Figure 10, M-O.

Material. — One cranium (PMO 117618) and one free cheek (PMO 117619) from Locality 3, Damtjern, GR 574014.

Discussion. — The shape of the glabellar lobes, the deep 1P and 2P furrows, and the 3P reduced to a pit far forwards on the glabella are features which suggest that the cranium (Fig. 10, M, N) belongs to *Ectenonotus*, species of which are known from the Whiterock Stage of Nevada, California, Quebec, western Newfoundland (Whittington 1961; Ross 1967), western Ireland, and Spitsbergen (Fortey

1980). Species identification is mainly based on the number of pygidial segments, but features of the glabellar lobes and furrows are also important. Thus the type species, *E. westoni* (Billings, 1965) (see Whittington 1961, p. 915, pl. 99, figs. 1, 4, 7) and *E. whittingtoni* Ross (Whittington 1961, pl. 99, figs. 5, 11, 13; Ross 1967, pl. 7, figs. 33, 34, pl. 8, figs. 4-9) do not have a pit-like 3P, while *Ectenonotus* sp. (Whittington 1961, pl. 100, figs. 1, 2, 5) from the upper Cow Head Group, Newfoundland has, as does *E. connemarius* Reed, 1909 from western Ireland and Spitsbergen (Fortey 1980, pl. 21, figs. 1,2). The present material resembles the upper Cow Head specimen in having a more pointed frontal glabellar lobe rather than the rounded lobe in *E. connemarius*.

Now that the present cranium has been found, it seems more likely that the incomplete pygidium figured as 'pliomerid pygidium A' by Bruton (1974, p. 112, fig. 17, H) belongs to *Ectenonotus*.

Family PTERYGOMETOPIDAE Reed, 1905

Genus *CALYPTAULAX* Cooper, 1930

Type species: *Calyptaulax glabella* Cooper, 1930

Calyptaulax cf. *C. incepta* Whittington, 1965

Figure 11, E.

Material. — One cephalon (PMO 117624) from Locality B, Østlund, GR 473988, one cephalon, one pygidium (PMO 93474-5), and one free cheek (PMO 93476) described from Trotland by Bruton (1974), and one cranium (PMO 117626) from Locality 10', GR 525018, collected by R.B. Neuman, 22 June 1980.

Discussion. — The present cranium from Østlund (Fig. 11, E) is far more complete than that figured by Bruton (1974, fig. 17, A, C) from Trotland. The latter material, together with a pygidium and free cheek was considered to be much closer to the oldest known species, *C. incepta* Whittington (1965, p. 428, pl. 67, figs. 1-4, 6) from the lower Table Head Formation, western Newfoundland, than other species from younger rocks in North America (Cooper 1953; Ross 1967; Shaw 1968). The new cranium supports this comparison, and shows the glabellar lobation and furrows, shape of palpebral lobes, and size of eye lobes to be identical. If anything, *C. incepta* has a slightly longer (sag.), more pointed frontal glabellar lobe.

Chatterton & Ludvigsen (1976, p. 77) notes that *C. incepta* possesses a characteristic deep furrow around the base of the visual surface of the eye, and that this feature is lacking in younger species. The new cranidium does not show this clearly, but that figured by Bruton (1974, fig. 17, A-C, G) does. The presence of this furrow is one of several reasons which led Chatterton & Ludvigsen to assign *Calyptaulax* to the Pterygometopidae, followed here, rather than to the Dalmanitiniidae as proposed by Whittington (1962, 1965).

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Fig. 5. *Vehnia triangularis* (Reed) and *Archaeorthis* ? sp.

- A-T, *Vehnia triangularis* (Reed), all X5, from Locality 1 (Damtjern), GR 572 014, Neuman & Bruton collection, 1970.
- A-D, dorsal valve (PMO 116688) having cardinal process; internal mold, internal replica, external mold, external replica.
- E-H, dorsal valve (PMO 116689) showing impression of adductor muscle scars but lacking cardinal process; internal mold, internal replica, external mold, external replica.
- I-J, ventral valve (PMO 116690), internal mold, internal replica.
- K-L, ventral valve (PMO 116691), internal mold, internal replica.
- M-N, ventral valve (PMO 116692), internal mold, internal replica.
- O-P, articulated valves (PMO 116681) showing dorsal valve surface with uniform costellation and conjoined interareas; external mold, external replica.
- Q-R, articulated valves (PMO 116684), showing dorsal valve surface with pronounced median rib and conjoined interareas with chilidium overlapping pseudodeltidium; external mold, external replica.
- S-T, Articulated valves (PMO 116682), showing dorsal valve surface as in Q-R conjoined interareas with incompletely fused chilidial plates and pseudodeltidium; external replica, external mold.
- U-Y, *Archaeorthis*? sp., all X3.
- U-V, ventral valve (PMO 116646), internal mold, internal replica, from Locality 5 (Katugleåsen), GR 566008, collected by Bruton & Bockelie, 1975.
- W-X, dorsal valve (PMO 116645), internal replica, internal mold, locality as U-V.
- Y, cluster of ~27 articulated valves (PMO 116648); for plot of orientation of shells see Fig. 2; from Locality 1 (Damtjern), GR 572013, collected by Bruton & Bockelie, 1975.

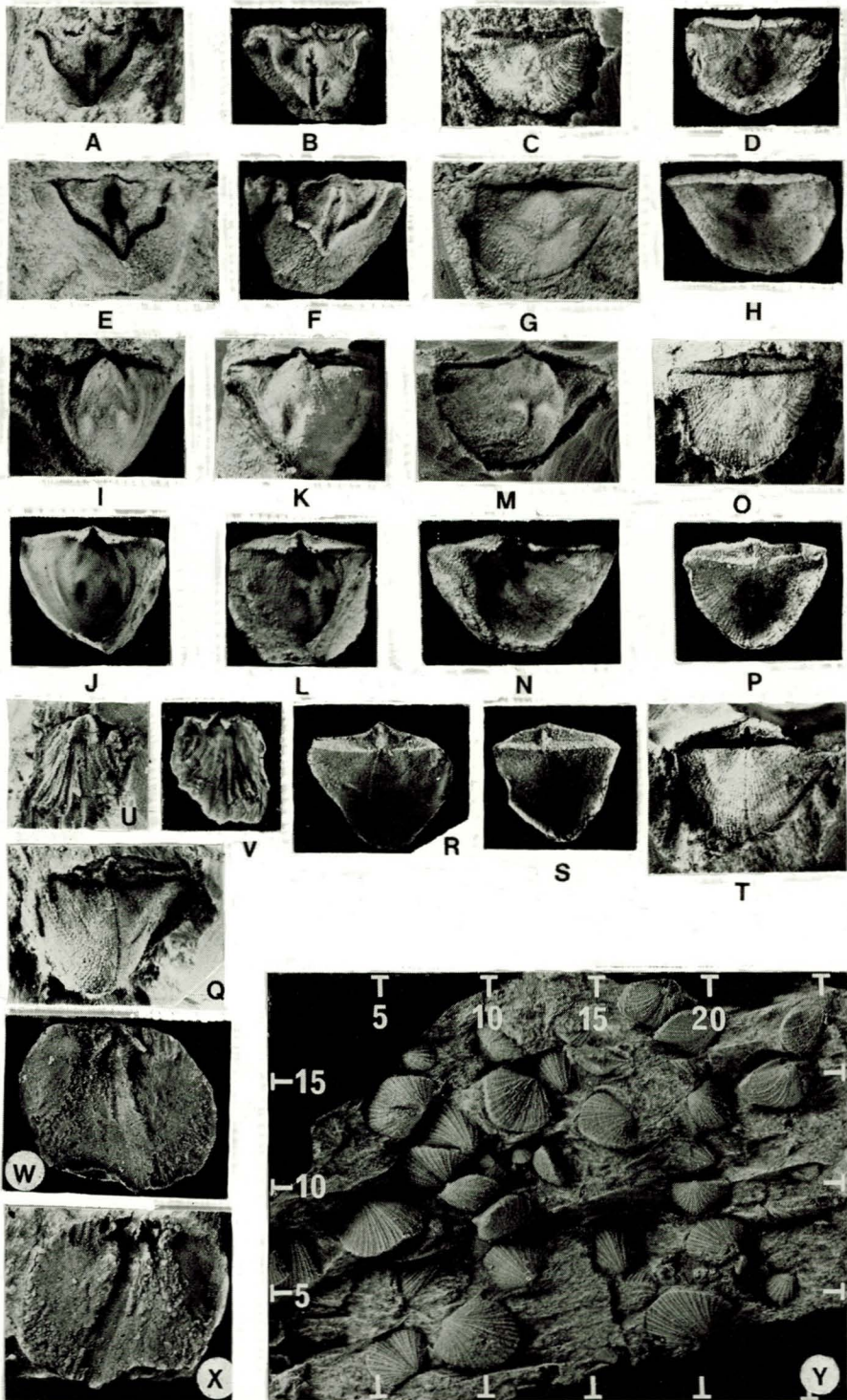


Fig. 6. *Rhysostrophia vagans* (Reed) and *Chaloupskia scabrella* n. gen., n.sp.

A-G, *Rhysostrophia vagans* (Reed), X2.

A-C, Articulated valves (PMO 116703), rubber replica from external mold of a fine-ribbed specimen, dorsal, ventral, and side views, Locality 2. (Damtjern), GR 572013, Bruton & Bockelie collection, 1975.

D-E, ventral valve (PMO 116706), internal mold, internal replica, Locality 5 (Katugleåsen), GR 566008, Neuman & Bruton collection, 1980.

F, articulated valves (PMO 116704), rubber replica from external mold of a specimen of intermediate ribbing density, dorsal view, Locality 2 as above.

G, articulated valves (PMO 116705), rubber replica from external mold of a coarsely ribbed specimen, Locality 2 as above.

Chaloupskia scabrella n.gen., n. sp., X2 except H at X4, all from Locality 5 (Katugleåsen), GR 566008, Neuman & Bruton collection, 1980.

H, incomplete ventral valve, internal mold, paratype (PMO 116719) showing pits formed by pustules marking teleolae.

I, ventral valve, internal mold, paratype (PMO 116662), internal mold.

J-K, articulated valves, holotype (PMO 116658), internal mold, ventral view, external mold, dorsal valve showing impression of radial ornament overgrown by comae.

L-M, dorsal valve, paratype (PMO 116663), internal mold, internal replica.

N-O, ventral valve, paratype (PMO 116661), internal replica, internal mold.

P-Q, dorsal valve, paratype (PMO 116664), internal mold, internal replica.

R-T, articulated valves, paratype (PMO 116659), of specimen lacking comae, external mold, ventral valve, external replica, posterior and ventral views.

U-V, ventral valve, paratype (PMO 116660), anterior part of external mold showing curtains of matrix between comae, internal mold.

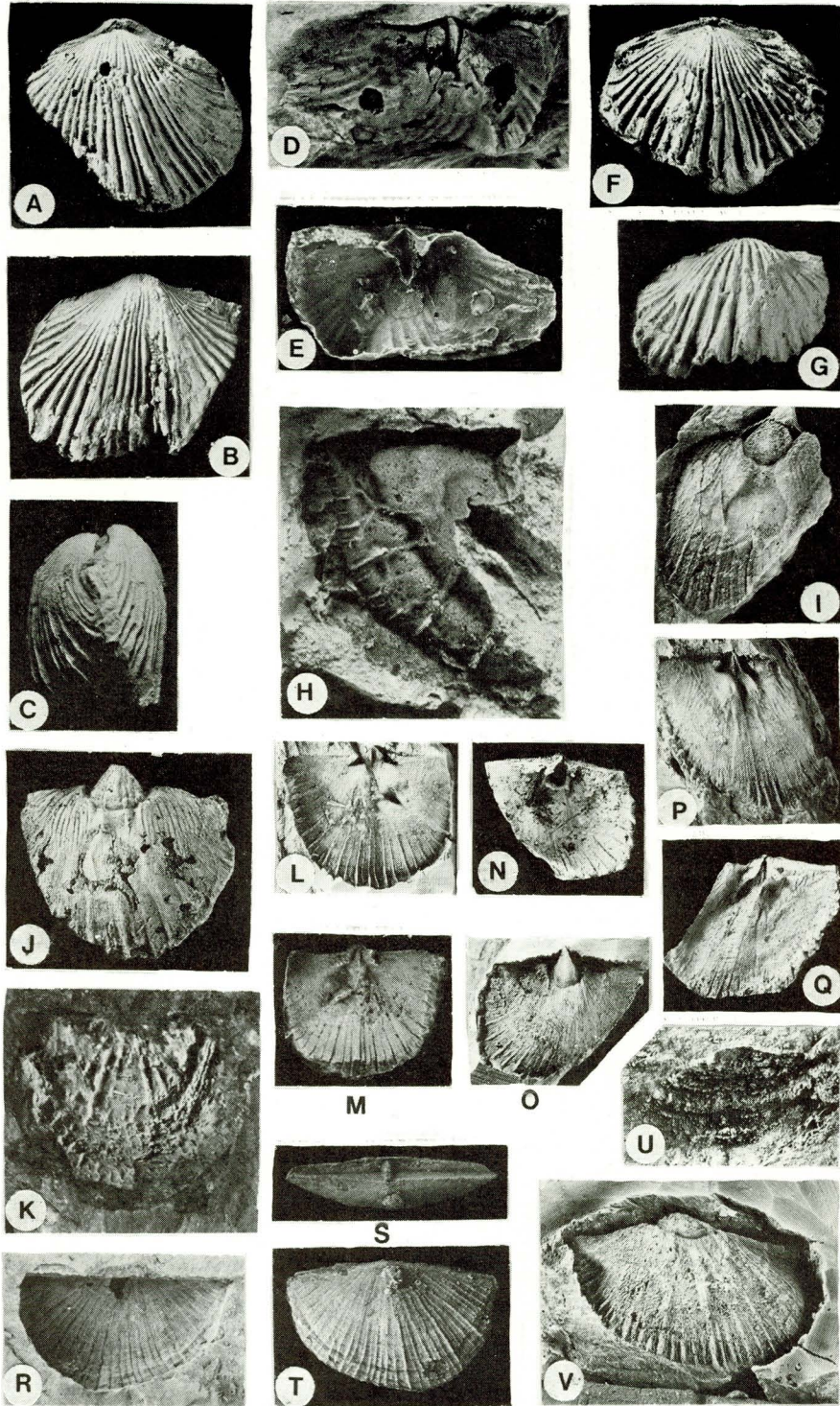


Fig. 7. *Rhabdostrophia striatisculpta* n.gen., n. sp., *Aporthophyla stoermeri* Neuman, and *Orthambonites* sp.

A-M, *Rhabdostrophia striatisculpta* n. gen., n. sp., all X2 from Locality B (Østlund). GR 473988, Neuman & Bruton collection, 1980.

A-C, dorsal valve, holotype (PMO 116693), internal mold, internal replica showing cardinalia, partial external mold.

D-G, articulated valves, paratype (PMO 116695), dorsal, posterior, anterior, and side views.

H-J, articulated valves, paratype (PMO 116694), ventral, posterior, and side views.

K-L, ventral valve, paratype (PMO 116696), internal mold, internal replica.

M, ventral valve, paratype (PMO 116697), internal mold.

N-S, *Aporthophyla stoermeri* Neuman, from Locality B (Østlund), GR 473988, Neuman & Bruton collection, 1980; continued on fig. 8.

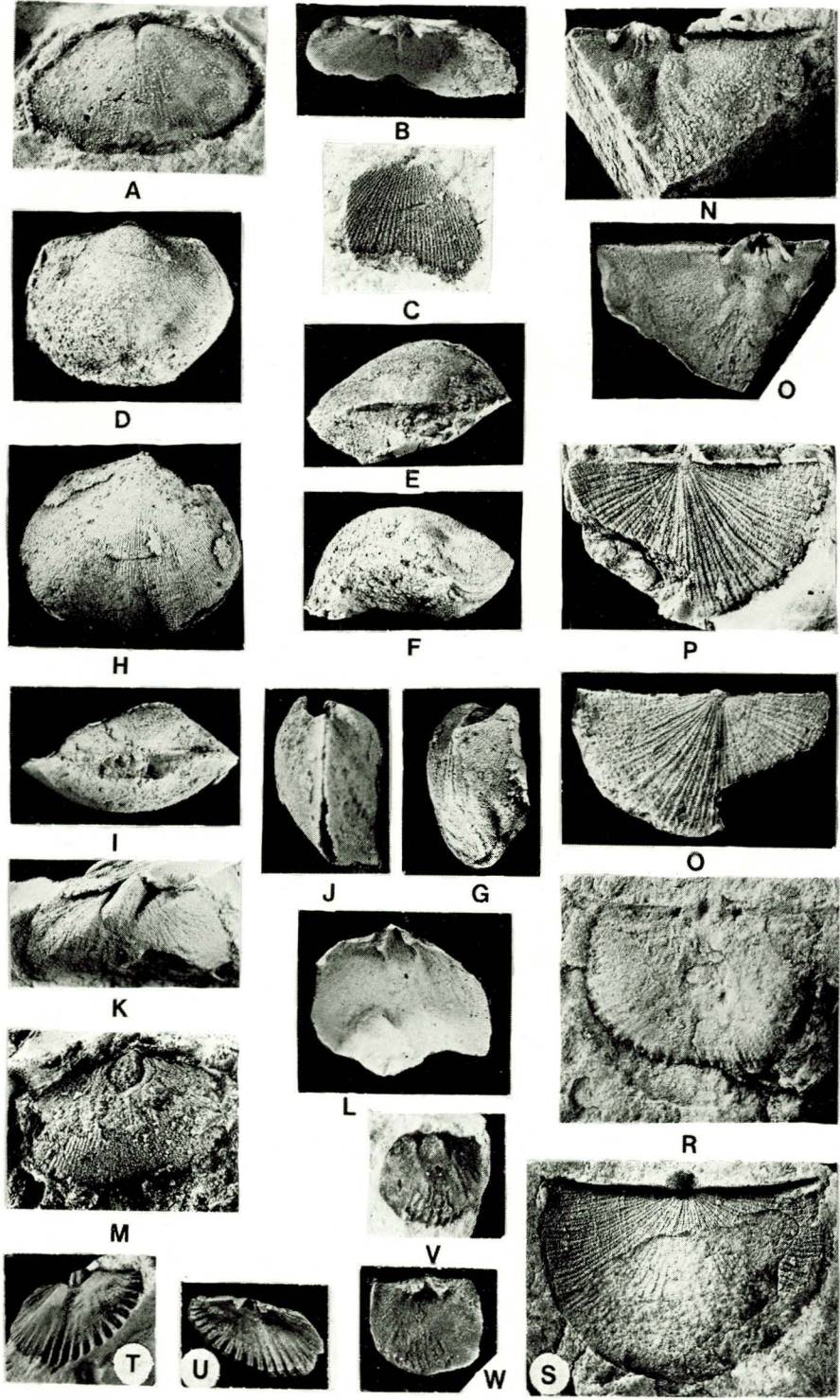
N-Q, dorsal valve, (PMO 116652), internal mold, internal replica, external mold, external replica, X2.

R-S, dorsal valve (PMO 116653), internal mold, external mold, X1.5.

T-W, *Orthambonites* sp., X2. Locality 5 (Katugleåsen), GR 566008, Neuman & Bruton collection, 1980.

T-U, dorsal valve (PMO 116650), internal mold, internal replica.

V-W, ventral valve (PMO 116651), internal mold, internal replica.



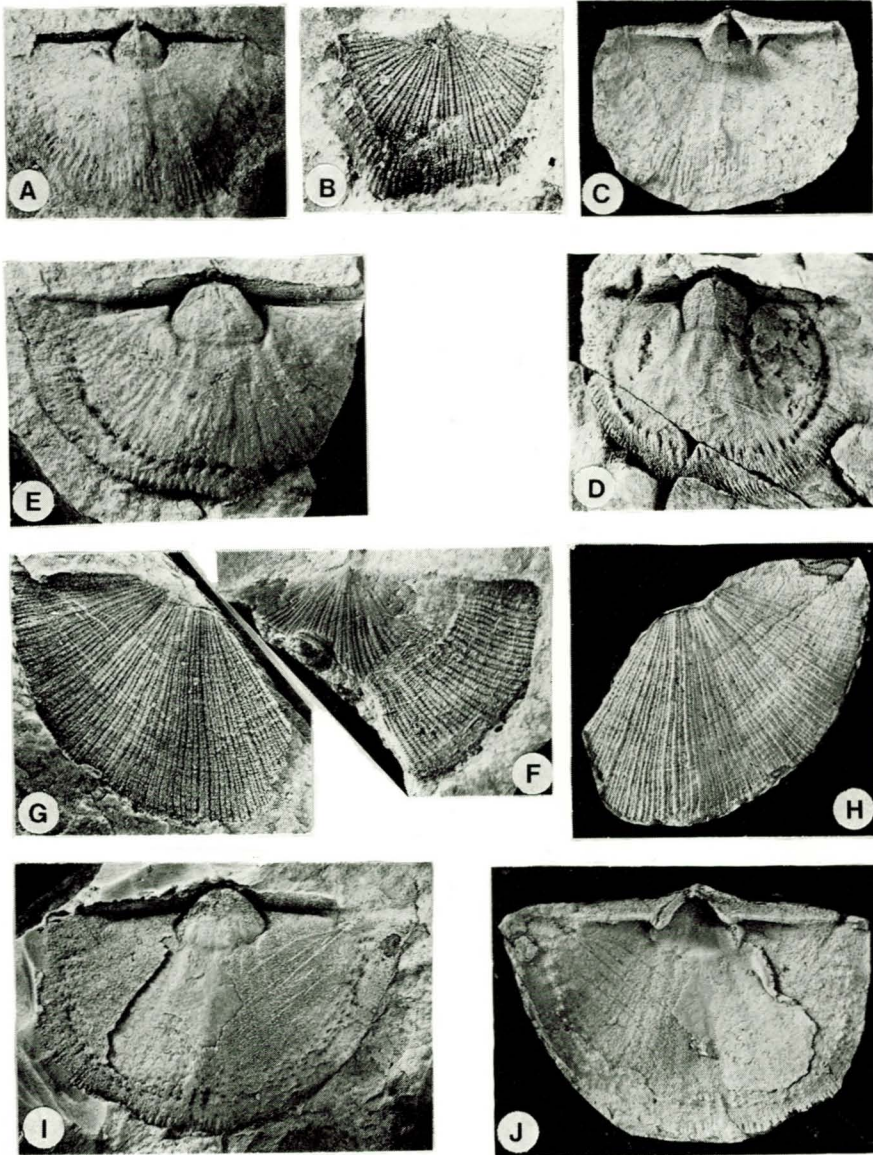


Fig. 8. *Aporthophyla stoermeri* Neuman, Locality B (Østlund), GR 473988, Neuman & Bruton collection, 1980, continued from Fig. 7.

A-C, ventral valve (PMO 116655), internal mold, external mold, internal replica, X2.

D, ventral valve (PMO 116656), internal mold, X1.5.

E-F, ventral valve (PMO 116657), internal mold, external mold, X1.5.

G-J, ventral valve (PMO 116654), external mold, external replica, internal mold, internal replica, X1.5.

Fig. 9. *Bockelia angusticostata* n. gen., n. sp., *Trondorthis strandi* Neuman, *Idiostrophia* sp., and *Stenocamara norvegica* (Reed), all X2.

A-N, *Bockelia angusticostata* n. gen., n. sp., all from Locality A (Bjørnlivatnet), GR 453968, Neuman & Bruton collections, 1970 and 1980.

A-C, dorsal valve, holotype (PMO 116671), internal mold, external mold, internal replica.

D, ventral valve, paratype (PMO 116675), internal mold.

E-G, ventral valve, paratype (PMO 116673), internal mold, external mold, internal replica.

H-J, ventral valve, paratype (PMO 116672), internal mold, internal replica, external mold.

K-M, ventral valve, paratype (PMO 116674), external mold, internal mold, internal replica.

N, articulated valves, paratype (PMO 116676), external mold showing dorsal and posterior surfaces; note impression of pseudodeltidium.

Idiostrophia sp.

O-P, articulated valves, external mold (PMO 116712), dorsal and lateral views, from Locality 1, GR 572013, collected by Bruton & Bockelie, 1975.

Trondorthis strandi Neuman, from Locality A (Bjørnlivatnet) as above.

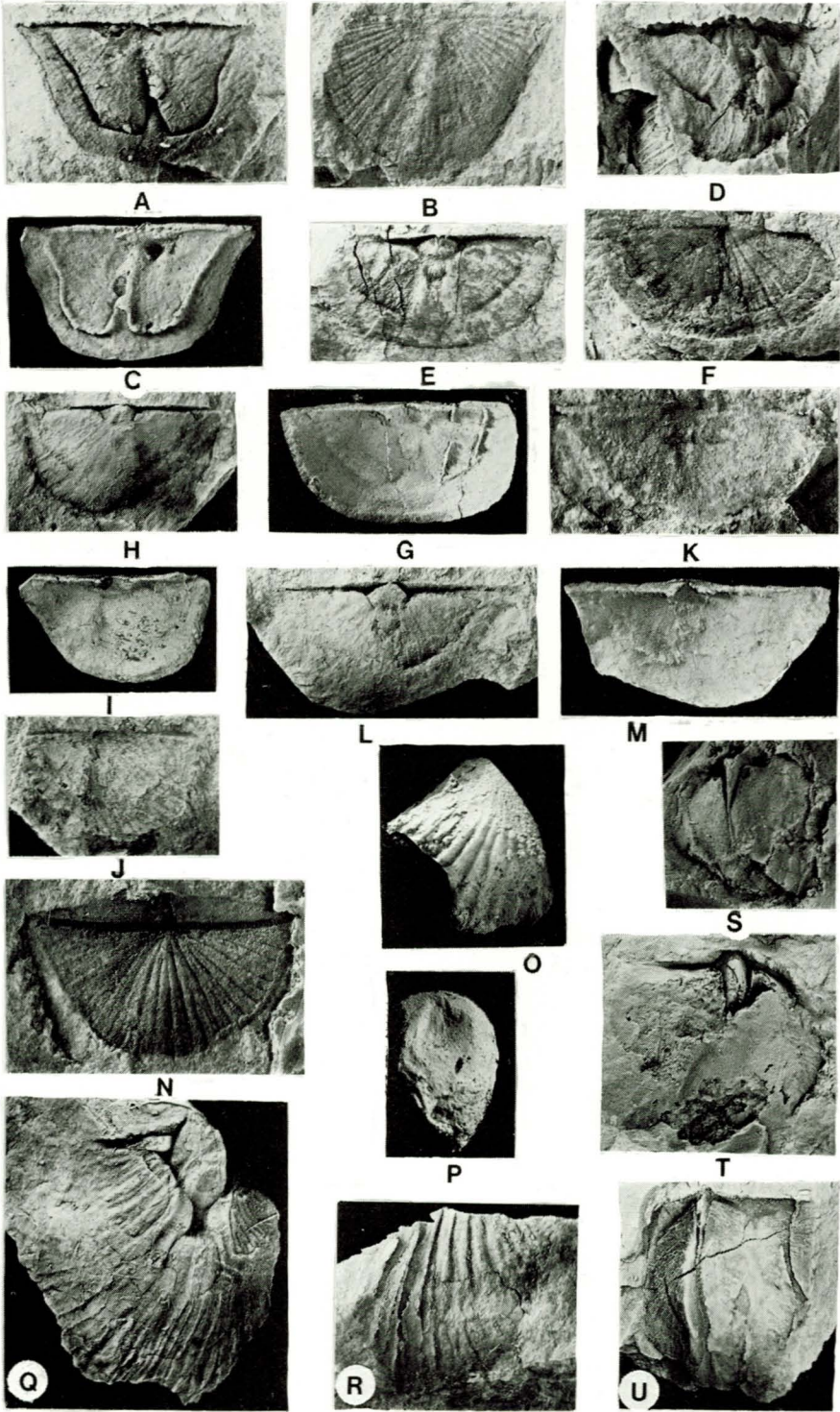
Q-R, ventral valve (PMO 116708), internal mold, partial external mold.

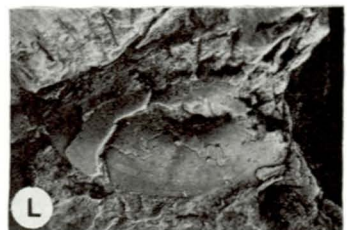
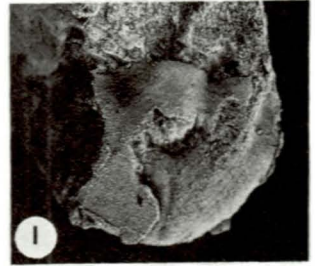
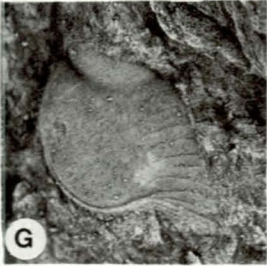
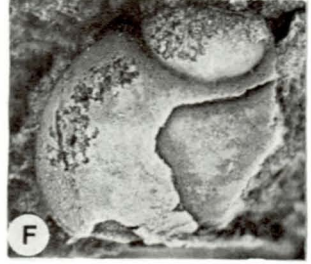
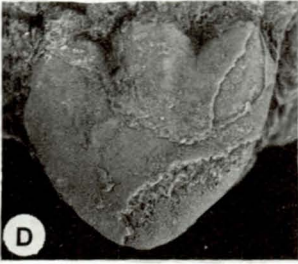
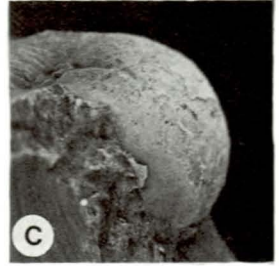
Stenocamara norvegica (Reed), from Locality A (Bjørnlivatnet) as above.

S, dorsal valve (PMO 116705), internal mold.

T, ventral valve (PMO 116707), internal mold.

U, dorsal valve (PMO 116706), internal mold.





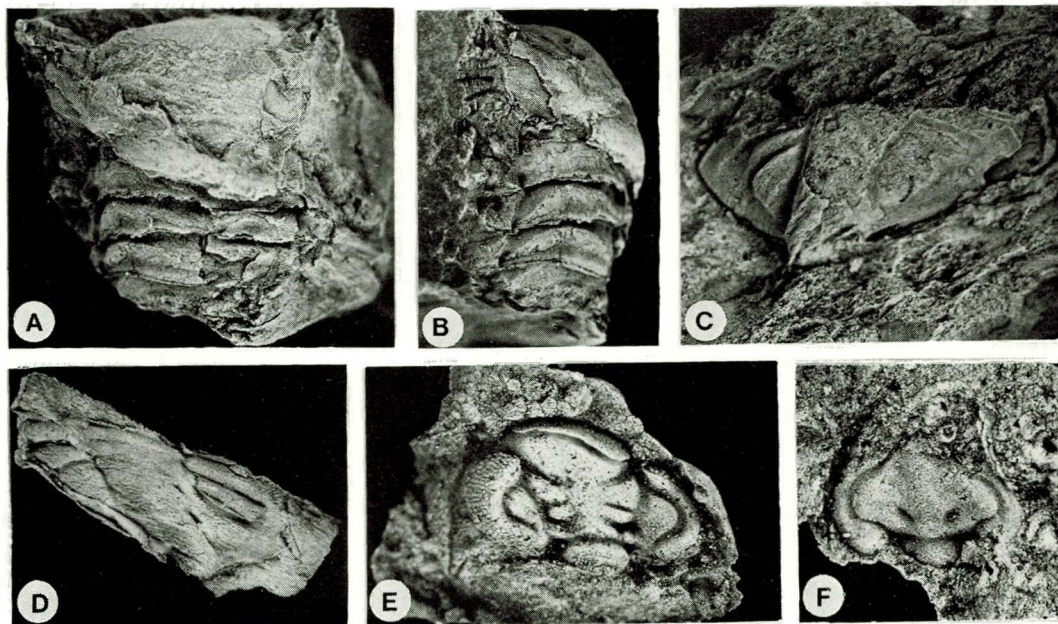


Fig. 11. *Nileus* sp. indet., *Goniotelina broeggeri* (Strand, 1932), *Calyptaulax* cf. *C. incepta* Whittington, 1965, and *Bloxyropsis* cf. *B. billingsi* Whittington, 1965.

Nileus sp. indet.

A-B, incomplete cranium and four thoracic segments (PMO 117609), dorsal and left-lateral views, X2. Locality 1, Damtjern, GR 572014, collected by D.L. Bruton, 1975.

Goniotelina broeggeri (Strand, 1932)

C, pygidium, internal mould (PMO 31841), X2. Katugleåsen, collected by W.C. Brøgger, 1876.

D, pygidium (PMO 31842), latex cast of external mould, dorsal view, X2. Locality and collection as C.

Calyptaulax cf. *C. incepta* Whittington, 1965

E, cephalon (PMO 117624), dorsal view, latex cast from external mould, X4. Locality B, Østlund, GR 473988, collected by D.L. Bruton & R.B. Neuman, 1980.

Bloxyropsis cf. *B. billingsi* Whittington, 1965

F, cranium (PMO 117623), immature growth stage, latex cast of external mould, X4. Locality and collection as E.

Fig. 10. *Iliaenus* cf. *I. auriculatus* Ross, 1967, *Iliaenus* sp. indet., and *Ectenonotus* sp. indet.

A-C, E-H, J-L, *Iliaenus* cf. *I. auriculatus* Ross, 1967.

A-C, cranium, internal mould (PMO 117614), dorsal, palpebral, and lateral views, X4. Locality 3, Damtjern, GR 574014. Collected by D.L. Bruton & J. F. Bockelie, 1975.

E, pygidium (PMO 117613), latex cast of external mould showing inner margin of doublure, X6. Locality and collection as A-C.

F, right free cheek (PMO 117616), lateral view, X8. Locality and collections as A-C.

G, right free cheek (PMO 117617), lateral view, X5. Locality and collection as A-C.

H, incomplete pygidium (PMO 32240), dorsal view, X4. Katugleåsen west, loose block, collection of T. Strand, 1927.

J, incomplete pygidium (PMO 32231), dorsal view, X2. Locality and collection as H.

K, pygidium (PMO 117612), dorsal view, to show doublure, X2. Locality 5. Katugleåsen, GR 566008, collected by D.L. Bruton, 1975.

L, pygidium (PMO 117611), oblique posterior view to show doublure, X2. Locality and collection as K.

D,I, *Iliaenus* sp. indet.

D, pygidium (PMO 117615), dorsal view, X4. Locality and collection as A-C.

I, pygidium (PMO 117610), dorsal view, prepared to show doublure, X6. Locality 6, Katugleåsen, north slope, GR 566008, collected by D.L. Bruton, 1980.

M-O, *Ectenonotus* sp. indet.

M,N, cranium (PMO 117618), internal mould, dorsal and left-lateral views, X4. Locality and collection as A-C.

O, partly exfoliated free cheek (PMO 1176198), left-lateral view, X3. Locality and collection as A-C.