

BRACHIOPODS FROM THE HIRNANTIAN STAGE (ORDOVICIAN-SILURIAN) AT PERCÉ, QUEBEC

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ABSTRACT. The following uppermost Ordovician-basal Silurian brachiopods of Hirnantian age from the White Head Formation at Percé, Quebec, Canada, are described and illustrated: *Hirnantia sagittifera*, *Dalmanella?* sp., *Kinnella kielanae*, *Eostropheodonta siluriana*, and *Plectothyrella crassicosta*. The occurrence is the first typical North European Hirnantian brachiopod fauna from North America to be identified at the specific level.

A TYPICAL brachiopod-dominated North European Hirnantian fauna was reported from the White Head Formation at Percé, Québec by Lespérance (in St-Julien *et al.* 1972; Lespérance 1974), and this paper describes those brachiopods, supplemented by additional material collected in 1974 and 1975. As this is the first typical North European Hirnantian brachiopod fauna from North America to be identified at the specific level, the species are illustrated, briefly described, and possible clinal variation assessed.

Hirnantian brachiopod faunas have been found widely in Northern Europe and the British Isles (see summaries by Wright 1968; Lespérance 1974). A similar but specifically distinct fauna in Morocco was described by Havlíček (1971). A related fauna may also occur in the Northern Shan States, Burma (Temple 1965). In North America typical Hirnantian brachiopod genera were reported from Maine by Neuman (1968), from Gaspé, Québec (Lespérance 1974), and in Illinois and Missouri by Amsden (1971, 1974), and a trilobite-dominated fauna of probable Hirnantian age in the White Head Formation by Lespérance (1968). The brachiopod species reported from Maine were not identified in Neuman (1968), but they may be typical representatives of the fauna. The localities in Maine lie in the same depositional belt as the Percé exposures (Ayrton *et al.* 1969). Amsden (1974) reported several genera in the Edgewood Group in Illinois and Missouri and linked it to Hirnantian faunas. However, all the Edgewood species are different from those in any confirmed Hirnantian fauna. Included in this mid-continent fauna are species of the late Ordovician North American Province genera *Thaerodonta* and *Diceromyonia*, species of the Hirnantian brachiopod fauna genera *Hirnantia*, *Dalmanella*, *Cliftonia*, and *Rafinesquina* (cf. *Eostropheodonta*) [sic], and species of North European Province genera such as *Dolerorthis*, *Mendacella?*, *Dicoelosia*, *Coolinia*, *Eospirigerina*, and a pentamerinid (*Brevilamnulella*) which may have been derived from the North European Province but certainly not from the North American late Ordovician Province. The Edgewood fauna may be of early Silurian (post-Hirnantian) age, as correlation with the type area in the United Kingdom during this interval is very tenuous. All Hirnantian genera reported by Amsden range well into the Silurian. Thus the Edgewood fauna could be a latest Ordovician endemic North American

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fauna with species derived from the *Hirnantia* Community and other North European Province species. On the other hand, and we consider this more likely, the fauna may be a Silurian one which includes a few hold-overs from the late Ordovician North American Province. In no way can it be considered the typical brachiopod-dominated *Hirnantia* Community.

THE PERCÉ FAUNA, ITS AGE AND PALAEOECOLOGY

Lespérance (1974) reported six brachiopod species in this fauna but in fact only five are present. The brachiopods *Hirnantia sagittifera*, *Kinnella kielanae*, *Eostropheodonta siluriana*, and *Plectothyrella crassicosta* are common elements of the Hirnantian fauna. *Dalmanella?* sp. may be related to *D. testudinaria*, another typical element of the fauna. Other members of the fauna from Percé include a cornulitid (Pl. 110, fig. 6), three poorly preserved conulariids, ten small favositid colonies (with very small corallites and corallum shapes that are either cylindrical or lozenge-shaped), and a pelmatozoan. Lespérance (1968) reported six specimens of *Phillipsinella parabola* (Barrande, 1846), and a pygidium of *Mucronaspis mucronata* (Brongniart, 1822) *sensu* Temple (1952) was collected recently.

Recently our knowledge of the faunas of the Hirnantian Stage has been expanded by Cocks and Price (1975, pp. 722–723) who ‘. . . believe that the *Hirnantia* fauna is best interpreted as representing an animal community comparable with those described by Ziegler *et al.* (1968) . . .’. However, trilobites very often occur with brachiopods in a particular assemblage, but in others trilobites and brachiopods occur separately, a point forcibly made by Lespérance (1974). Both trilobite-dominated and brachiopod-dominated faunas were assigned to the *Hirnantia* fauna and community by Cocks and Price (1975), but we prefer to recognize separate communities and believe this conforms more closely to the community usage of Ziegler *et al.* (1968). The trilobite-dominated community is here termed the *Mucronaspis* Community, and is gradational with the *Hirnantia* Community. Gradations such as this are common in Recent level-bottom marine communities. The gradation may also vary with time, but this point needs further field work to be proven.

The *Hirnantia* Community described in this paper is a shallower-water community than the *Mucronaspis* Community (with a few graptolites and no brachiopods) which was described previously by Lespérance (1974) from the Portage River area, 17 km from Percé. The relation between these distinct communities is not inconsistent with what is known of the Scandinavian occurrences. We agree with Cocks and Price (1975) that what has previously been referred to as the *Hirnantia* fauna is best considered as a community (or communities), and we suggest that in the future the term *Hirnantia* Community be used exclusively in place of ‘*Hirnantia* fauna’. Application of the term Hirnantian fauna to any fauna from the Hirnantian Stage is appropriate and is not in error (as maintained by Cocks and Price 1975, p. 721). This usage is simply a reflection of the age of the fauna involved. For example, another Hirnantian fauna, not previously mentioned, is the *Holorhynchus* Community of Scandinavia (see Boucot 1975).

In the Portage River area near Percé, Lespérance (1974) reported the association of Hirnantian trilobites with a Silurian graptolite, *Climacograptus rectangularis*-

medius, indicating that the Hirnantian fauna is both uppermost Ordovician and lowermost Silurian, when correlated with the type sections in the United Kingdom. *C. rectangularis-mediis* refers to specimens belonging to a single species, but for which the terms *rectangularis* and *mediis* are synonyms according to Dr. J. Riva (pers. comm.). Rickards (in Cocks and Price 1975, p. 722) believes this is an Ordovician graptolite but until he gives a systematic description of the specimens in question we will follow Riva's identification and age assignment. Ingham (1974, p. 59) cited Lespérance (1974) as advocating the inclusion of the Hirnantian Stage in the Silurian. In fact Lespérance only suggested this placement as *one* of several possible alternatives, while noting (Lespérance 1974, fig. 2) that as now defined the Hirnantian Stage includes the systemic boundary. As the faunas from the mid-Ashgill to the mid-Llandovery become progressively more cosmopolitan, we now suspect that a systemic boundary drawn near the mid-Llandovery will ultimately prove to be the easiest to recognize on a world-wide scale.

It has still not been established that the top of the Hirnantian Stage corresponds with the base of the Llandovery Series. No marker point (Harland *et al.* 1972, p. 299) has been established for the standard stratigraphical scale within the Foel y Ddinas Mudstone (the type Hirnantian) of the Bala area, or for that matter in the Llandovery area. A section along forestry roads immediately north of the stream Cwm Hirnant (and immediately north of the type Hirnant Limestone quarry) has yielded a *Hirnantia* Community assemblage and is overlain (10 m above) by graptolites of the Upper Llandovery, including *Monograptus* of the *pridon* group (pers. comm., Dr. R. B. Rickards, Sept. 1974). This locality is near the locality Bwlch yr Hwch which supposedly contains *Glyptograptus persculptus*, discussed in Bassett *et al.* (1966, p. 256). As correlation between the Bala area and Dobb's Linn is at best tenuous, the type Hirnantian may consequently extend into the Llandovery, a point previously made by Lespérance (1974). This only serves to reinforce Cocks and Price's (1975) contention that occurrences of the *Hirnantia* Community (and the *Mucronaspis* Community) are probably not all of the same age.

Finally, it must be noted that should the Ellis Bay Formation faunas of Anticosti, in the North American zoogeographic province, prove to be partly of the same age as the Hirnantian Stage, the term Gamachian (Twenhofel 1928) has priority in the standard stratigraphical scale (Harland *et al.* 1972) over the term Hirnantian, which was originally suggested as a *post-Ashgill* time-stratigraphical term (Bancroft 1933).

PALAEOZOOGEOGRAPHY

The Hirnantian localities in Gaspé and Maine lie on the American margin of the Proto-Atlantic Ocean (Wilson 1966; Bird and Dewey 1970; McKerrow and Ziegler 1971, 1972). A recent review of the Taconic Orogeny in Québec (St-Julien and Hubert 1975) reveals that in the late Ordovician these areas lay oceanward (present-day east) of a tectonic welt formed during closure of a basin behind the arc. All species identified in the Percé collections are known in the North European Hirnantian Stage. The presence of this fauna on the eastern margin of North America is significant as it implies that distribution of species was possible across the closing Proto-Atlantic Ocean. The Percé fauna is more closely related to the North European Hirnantian

fauna of Great Britain and Ireland than to that of Sweden or Poland. *Eostropheodonta siluriana* is known only in Great Britain and possibly Ireland. Details of the morphology of *Plectothyrella crassicosta* (described below) are most similar to the morphology of members of the species from Great Britain (indicating that clinal variation may have existed). Therefore faunal communication through Great Britain appears very likely. The Percé fauna can be distinguished from the South European–North African Hirnantian fauna by distinctive species of *Eostropheodonta* and *Plectothyrella* discussed below.

LOCALITY

The fossils were collected from a talus slope beneath the vertical cliff along the sea, north of Cap Blanc (Military Grid Reference 090729) shown on the Percé Topographic Map (22A/9 Edit. 2). The locality was discussed by Lespérance (1974). The fossils are from a 30-m band of steeply dipping red mudstones in the lower part of a 610 m continuously exposed section dominated by thinly bedded micritic limestones. To the north the mudstones are underlain by limestones with 'Lower or Middle' Ashgill faunas. To the south, at the top of the mudstones, is a minor fault above which are Llandoverly limestones. In 1974 the accessible portions of the cliff outcrop were carefully examined by the authors, but no fossils could be found in place. The fossils recovered in 1974 were localized on one part of the talus slope and were probably weathered from a single bed or a closely spaced group of beds. In 1975, on the other hand, fossils were present on all portions of the talus. The fossils were clearly derived from the overlying cliffs because the lithology of the talus matches the bedrock, and the talus was actively accumulating while the collections were made.

SYSTEMATIC PALAEONTOLOGY

Family DALMANELLIDAE Schuchert, 1913
Genus DALMANELLA Hall and Clarke, 1892
Dalmanella? sp.

Plate 109, figs. 1–2

1974 ?*Dalmanella testudinaria* (Dalman); Lespérance, p. 12.

Description. Ventribiconvex. Dorsal sulcus faint. Hinge line narrow, equalling less than half maximum shell width which occurs near mid-length. Outline evenly rounded or slightly transverse. Largest individual 13 mm long. Ventral interarea apsacline; dorsal interarea anacline. Angular costellae increase in size anteriorly; new costellae originate through bifurcation. Four to six costellae in space of 2 mm measured 5 mm from beak. Cardinal process bilobed.

Material. Seven individuals were recovered.

Discussion. The bilobed cardinal process and external ornament are reminiscent of species of *Dalmanella* recorded in the Hirnantian fauna from other areas, but no identification can be made in the absence of specimens with the interiors preserved.

Family SCHIZOPHORIIDAE Schuchert and LeVene, 1929
 Subfamily SCHIZOPHORIINAE Schuchert and LeVene, 1929
 Genus HIRNANTIA Lamont, 1935
Hirnantia sagittifera (Mc'Coy, 1851)

Plate 109, figs. 3-11

- 1851 *Orthis sagittifera* M'Coy, p. 398.
 1935 *Hirnantia sagittifera* (M'Coy); Lamont, p. 313, pl. 7, figs. 20-22.
 1974 ?*Hirnantia sagittifera* (M'Coy); Lespérance, p. 12.

Exterior. Dorsibiconvex. Hinge line wide; maximum shell width slightly in front of cardinal extremities. Dorsal sulcus shallow, narrow, poorly defined. Costellae rounded in cross-section, much wider than interspaces. New costellae commonly originate through bifurcation but occasionally by intercalation. Three costellae occupy space of 1 mm measured 5 mm from beak. Very fine parvicostellae in interspaces (file of Temple 1965). Parvicostellae and fine growth lines best preserved in outer moulds. Both interareas long, curved, laterally striate. Ventral interarea apsacline; dorsal interarea anacline.

Ventral interior. Teeth supported by strong dental plates diverging widely toward front. Low ridges extending short distance forward from dental plates bound muscle field. Weakly impressed muscle field confined to posterior quarter of valve. Adductor muscle scars occupy median third of muscle field, but extend forward only two-thirds length of diductor muscle scars. Adductor muscle scars bounded laterally by low, nearly parallel ridges. In addition, two very faint ridges are parallel to the sides of adductor muscle scars dividing them into equal thirds. Pedicle callist small, transversely striate. External ornament faintly impressed on internal surface.

Dorsal interior. Simple, bulbous cardinal process supported by high, short septum that continues anteriorly as very broad, rounded ridge extending to about mid-length. In one specimen minute septa lie on either side of cardinal process (Pl. 109, fig. 11). Similar septa in other schizophoriids were termed accessory cardinal processes by Schuchert and Cooper (1932, pl. A, fig. 14) and similar structures were found by Johnson (1970, pl. 9, fig. 13), in another species. Brachiophores tall; brachiophore support plates diverge anteriorly between 45 and 60 degrees. Sockets conical, supported by fulcral plates attaching directly to brachiophore supporting plates. Muscle field poorly preserved.

Material. Forty-one specimens were recovered including the interiors of ten dorsal and nine ventral valves.

Discussion. Small individuals of *H. sagittifera* can be distinguished from those of the small schizophoriid *Kinnella kielanae* by their much lower ventral valve, their dorsal interarea which is anacline rather than orthocline, and a weaker median ridge in the dorsal valve. *H. sagittifera* has been widely reported from the Hirnantian of Ireland, Great Britain, Poland, Sweden, Bohemia, and Morocco. Neuman (1968) reported *Hirnantia* sp. in Aroostook County, Maine.

H. noixella Amsden, 1974 from the Noix Limestone of Missouri is a very small species that differs from *H. sagittifera* in having costellae that are more rounded in cross-section and a more bulbous cardinal process. *H. noixella* does not grow large enough to develop the characteristic ventribiconvex valves of typical *Hirnantia* species (Amsden 1974). *H. senecta* (Hall and Clarke, 1892) from the Clinton Group of Reynales Basin, New York, and *H. cf. H. senecta* from the Brassfield Formation at Clinton, Tennessee, differ from *H. sagittifera* in having finer radial ornament, stronger ridges bounding the front of the ventral muscle field, a stronger dorsal median ridge, and better-defined dorsal muscle scars (see Walmsley *et al.* 1969).

Genus KINNELLA Bergström, 1968
Kinnella kielanae (Temple, 1965)

Plate 109, figs. 12-19

- 1965 *Hirnantia? kielanae* Temple, pp. 401-407, pl. 8, figs. 1-7; pl. 9, figs. 1-8; pl. 10, figs. 1-8; pl. 11, figs. 1-7; text-figs. 2c-f, 3a-b.
 1968 *Kinnella kielanae* (Temple); Bergström, p. 11, pl. 4, figs. 3-6.
 1974 *Kinnella kielanae* (Temple); Lespérance, p. 12.

Exterior. Shells ventribiconvex, ventral valve highly arched. Transverse, length about three-quarters width. Hinge line about two-thirds of maximum shell width, which occurs near mid-length. Dorsal sulcus shallow, poorly defined. Ventral interarea curved, apsacline, approaching catacline, very long, about half length of ventral valve. Dorsal interarea curved, orthocline, about one-third length of ventral interarea. Delthyrium very narrow. About four costellae in a space of 1 mm measured 5 mm from the ventral beak. Largest shell 9 mm long.

Ventral interior. Small, transversely striate pedicle callist. Teeth supported by anteriorly divergent dental plates. Broad, low ridges extending from front of dental plates surround muscle field. Muscle field confined to posterior half of valve. Diductor muscle scars enclose elongate adductor muscle scars.

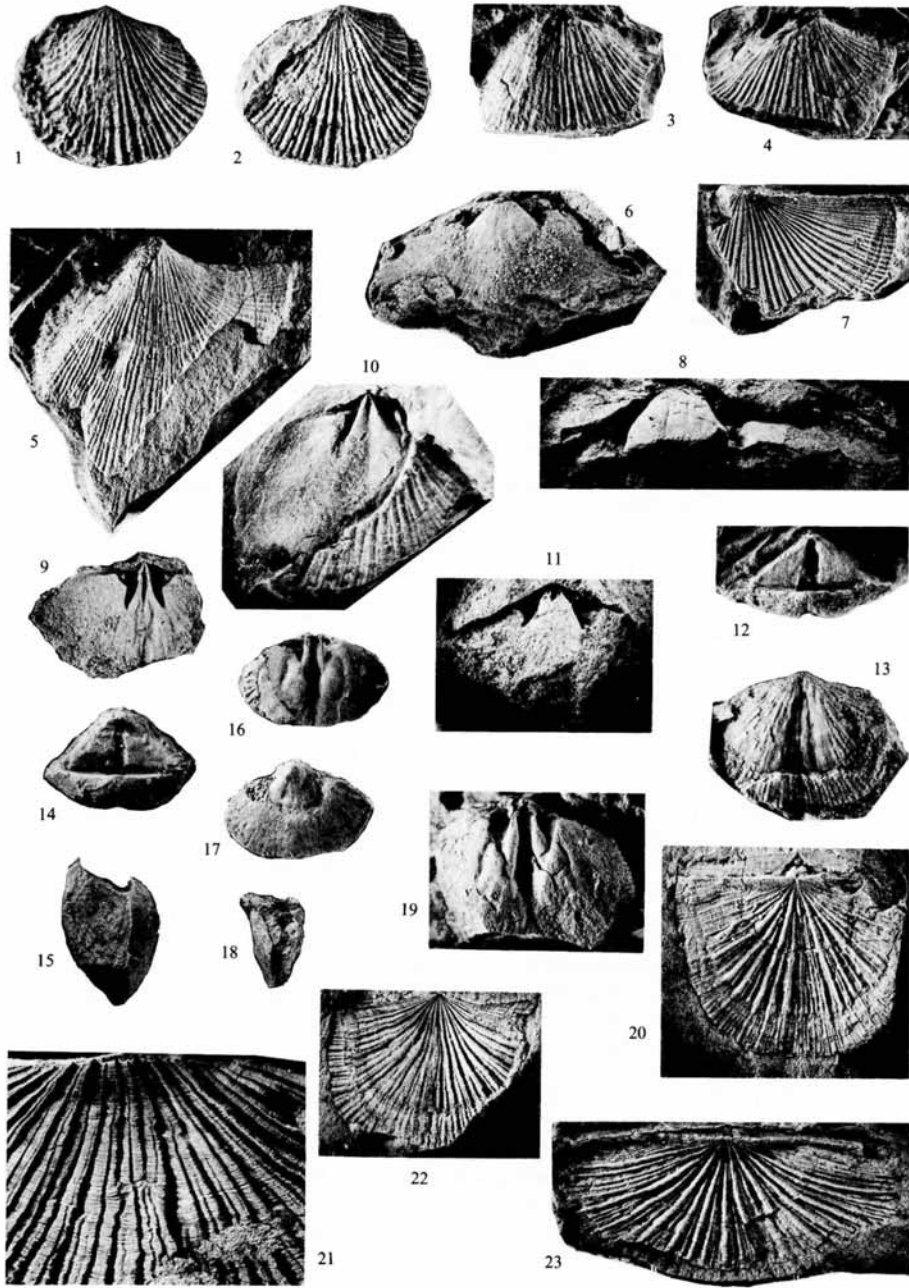
Dorsal interior. Strong, broad median ridge extends from base of cardinal process to anterior margin. Adductor muscle scars reach well beyond mid-length, divided by faint transverse ridges into small posterior and much larger anterior portions. Muscle field bounded laterally by low, rounded ridges extending forward from bases of brachiophores. Tip of cardinal process not preserved. Sockets nearly parallel to hinge line.

Material. Twenty-four specimens were recovered including the interiors of three dorsal and three ventral valves.

Discussion. Specimens in our collections conform very closely to *K. kielanae* from Poland (Temple 1965), Great Britain (Temple 1965), Bohemia (Marek and Havlíček 1967), and Sweden (Bergström 1968). Temple (1965) suggested that this species may be conspecific with *Skenidium? medlicotti* Reed, 1915 from the 'Llandovery' of Panghsapye, Burma. Bergström (1968) noted several major differences between illustrated specimens of *S.? medlicotti* and *K. kielanae*.

EXPLANATION OF PLATE 109

- Figs. 1-2. *Dalmanella?* sp. 1-2, ventral and dorsal exterior of GSC 42216, $\times 2.0$.
 Figs. 3-11. *Hirnantia sagittifera* (M'Coy). 3-4, ventral and dorsal exterior of GSC 42217, $\times 2.5$. 5, ventral exterior of GSC 42218, $\times 1.75$. 6, ventral interior mould of GSC 42219, $\times 2.5$. 7, ventral exterior mould of GSC 42220, $\times 2.5$, fine growth lines present. 8, ventral interior mould of GSC 42221, $\times 2.5$. 9, dorsal interior mould of GSC 42222, $\times 2.5$. 10, dorsal interior mould with a fragment of the exterior shell surface of GSC 42223, $\times 2.5$, fine growth lines faintly visible. 11, dorsal interior mould of GSC 42224, $\times 2.5$, faintly showing minute septa lateral to the cardinal process.
 Figs. 12-19. *Kinnella kielanae* (Temple). 12-13, posterior and dorsal exterior of GSC 42225, $\times 3.0$. 14-15, posterior and lateral exterior of GSC 42226, $\times 3.0$. 16-18, dorsal ventral and lateral views of interior mould of GSC 42227, $\times 3.0$. 19, dorsal interior mould of GSC 42228, $\times 3.0$.
 Figs. 20-23. *Eostropheodonta siluriana* (Davidson). 20, dorsal exterior showing ventral interarea and chilidium, GSC 42229, $\times 1.75$. 21, mould of part of the exterior ornament of dorsal valve, GSC 42230, $\times 5.0$. 22, mould of the ventral exterior of GSC 42231, $\times 1.75$. 23, dorsal exterior of GSC 42232, $\times 1.75$.



LESPÉRANCE and SHEEHAN, *Hirnantia* fauna

Family EOSTROPHEODONTIDAE Havlíček, 1967
 Genus EOSTROPHEODONTA Bancroft, 1949
Eostropheodonta siluriana (Davidson, 1871)

Plate 109, figs. 20-23; Plate 110, figs. 1-5

- 1871 *Strophomena Siluriana* Davidson, p. 303, pl. 47, figs. 1-4.
 1953 *Stropheodonta (Eostropheodonta) siluriana* (Davidson); Williams, pl. 7, figs. 1-4.
 1974 *Eostropheodonta hirnantensis* (Davidson); Lespérance, p. 12.

Exterior. Dorsal valve slightly concave; ventral valve somewhat more strongly convex. Maximum curvature about 5 mm from beak of both valves. Transverse; three shells were ($l=18$ mm, $w=21$ mm), ($l=16$ mm, $w=19$ mm), ($l=20$ mm, $w=32$ mm). Postero-lateral margins slightly mucronate. Fourteen to eighteen primary costellae originate near beak. Costellae bifurcate anteriorly, but primary costellae remain much stronger than new costellae, producing fascicostellate ornament. Costellae high, very steep sided, sharp-crested, and narrower than interspace. Costellae on postero-lateral margins weak. Commonly fourteen to sixteen costellae in space of 5 mm measured 5 mm from beak. Growth lines well defined, densely spaced. Anacline, nearly orthocline ventral interarea tall, gently curved laterally, nearly completely striate. Dorsal interarea catacline. Chilidium large, medially grooved with transverse striae. No deltidium.

Ventral interior. Dorsal facing surfaces of teeth antero-posteriorly striate. Teeth supported by short, thick dental plates diverging strongly toward front. No denticles observed. Flaring muscle field weakly impressed, bounded postero-laterally by dental plates and short low ridges extending forward from dental plates. Interspaces between costellae impressed on interior of valve forming low ridges; on crests of these ridges small tubercles (probably overlying pseudopunctae) most numerous anteriorly.

Dorsal interior. Only fragments of moulds of four dorsal interiors found. Bilobed cardinal process flanked by small socket plates. Slim blade between cardinal process lobes apparently supported chilidium. Short, low, broad ridge in front of cardinal process.

Material. Forty-five specimens were recovered including the interiors of four dorsal and eight ventral valves.

Discussion. Havlíček (1967) restudied *Eostropheodonta* and established the family Eostropheodontidae. Harper (1973) did not comment upon Havlíček's classification, but suggested that *Eostropheodonta* was possibly derived from a different ancestor than that of *Leptostrophia*, the first of the Stropheodontidae. If *Eostropheodonta* had a different ancestor from the stropheodontids, Havlíček's family Eostropheodontidae is consistent with the evolution of these groups.

The similarity of *E. siluriana* and *E. hirnantensis* has been commented on by Marr (1907), Elles (1922), and Wright (1968), who questioned the presence of two distinct species. The specimens under study are assigned to *E. siluriana* because of their very coarse fascicostellate ribbing. Wright (1968) suggested that the coarse ribbing may be related to the habitat as the ribbing pattern of *E. siluriana* is typically found in non-calcareous mudstones as is also the case here. The species need restudy; it may be that only a single species is present, but no intergradation between these two species (or morphotypes) is known, and they are treated as distinct with the data at hand.

E. hirnantensis from Sweden (Bergström 1968) differs from representatives of both species from other areas in lacking a median groove on the chilidium. Polish and Bala specimens of *E. hirnantensis* are distinguished by a faint fold and sulcus in the posterior of the shells (Temple 1965, and Université de Montréal collections). Havlíček (1971) proposed *E. squamosa* for specimens from Bohemia previously assigned to

E. hirnantis; he also reported the species from the Ashgill of Morocco. This species, together with *E. jebilentensis* Havlíček (1971), *E. tafilaltensis* Havlíček (1971), *E. intermedia* Havlíček (1971), and *E. filicosta* Havlíček (1971) all from Morocco, can be distinguished from the species under study by their much finer costellae. *E. discumbata* Cocks and Brunton 1970 (in Cocks *et al.* 1970) from the late Ashgill or possibly lower Llandovery of South Africa differs from *E. siluriana* in having finer ornament, a narrower ventral muscle field, and in lacking a chilidium. *Rafinesquina?* *stropheodontoides* (Savage, 1913) is another weakly ribbed species which Amsden (1974) believes may be related to species of *Eostropheodonta*. *E. siluriana* has been reported previously only from the Hirnantian brachiopod fauna in the north of England; Wright (1968) notes its possible presence at Kildare, Ireland.

Family ANCISTORRHYNCHIDAE Cooper, 1956
 Subfamily PLECTOTHYRELLINAE Bergström, 1968
 Genus PLECTOTHYRELLA Temple, 1965
Plectothyrella crassicosta (Dalman, 1828)

Plate 110, figs. 6-21

- 1828 *Atrypa?* *crassicostis* Dalman, pp. 47-48.
 1965 *Plectothyrella platystrophoides* Temple, pp. 412-415, pl. 20, figs. 1-5; pl. 21, figs. 1-10.
 1967 *non Plectothyrella platystrophoides* (Temple); Marek and Havlíček, p. 284, pl. 1, figs. 14-17, 19.
 1968 *Plectothyrella crassicosta* (Dalman); Bergström, p. 19, pl. 7, figs. 5-8.
 1974 *Plectothyrella platystrophoides* Temple; Lespérance, p. 12.

Exterior. Ventribiconvex, transverse; no specimens well enough preserved to permit accurate length-width measurements. Dorsal fold, ventral sulcus, but in posterior 3-5 mm faint ventral fold and dorsal sulcus. Costae strong, angular, steep sided. Eight to ten costae on flanks. Costae on flanks originate near beak, do not bifurcate anteriorly. Two strongest costae on ventral valve bound sulcus. Median costa in sulcus. Eight to 10 mm from beak a weak costa is inserted on each side of median costa. A single atypical specimen has two costae the full length of the sulcus (specimen not illustrated). Dorsal fold formed by two strong costae bifurcating 12-15 mm from beak. Growth lamellae closely spaced, strongest anteriorly, best preserved in moulds. Hinge line wide for a rhynchonellid.

Ventral interior. Cyrtomatodont teeth small, bulbous. Dental plates converge basally, engulfed in secondary shell. Pedicle chamber in apex of shell and perched high above deeply impressed muscle field. Triangular muscle field expands anteriorly at about 30°, only faintly impressed in front. Adductor and diductor muscle scars not differentiated. Two grooves in muscle field parallel lateral margins of muscle field. Interspaces between costae strongly impressed as ridges in front of muscle field, but secondary shell lines posterior half of shell, obscuring impress of external ornament.

Dorsal interior. Cardinal process, crural plates, and inner hinge plates lacking. Sockets raised well above floor of valve, bounded by outer socket ridges and massive inner socket ridges. Crural bases large. Crura cylindrical, long, very large. High, narrow, median ridge set well in front of cardinalia, lower at mid-length, beyond which it is merely impress of median interspace of external ornament. Interspaces between costae strongly impressed on interior.

Material. Ninety-four specimens were recovered, including the interiors of eight dorsal, seventeen ventral, and six conjoined valves.

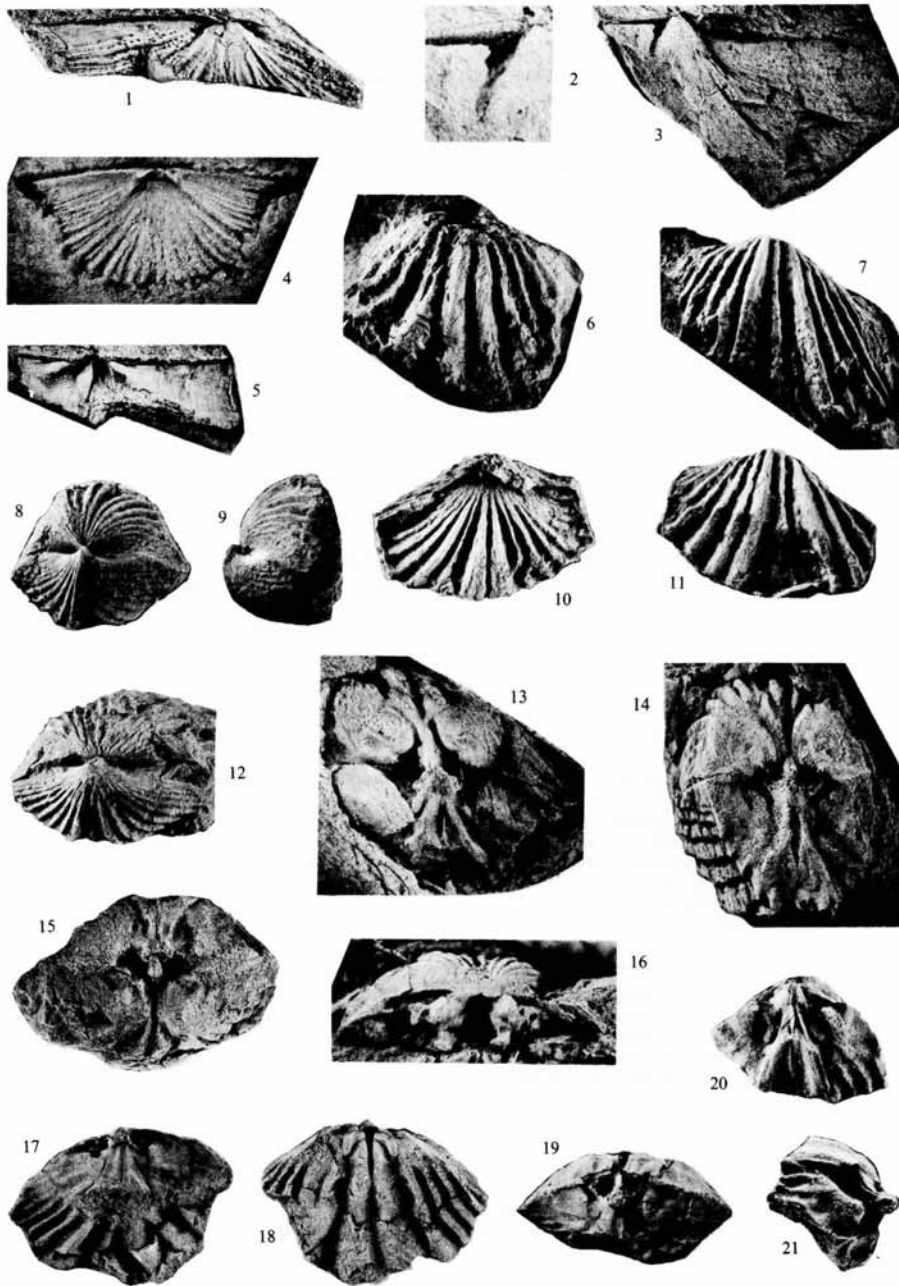
Discussion. The internal features of the dorsal valve are clearly rhynchonelloid, confirming Bergström's (1968) assignment of the genus to that order. Furthermore,

Bergström's assignment of this genus to a separate subfamily within the Ancistrothyrellidae appears sound. Three species of *Plectothyrella* have been described: *P. crassicosta*, *P. haughtoni*, and *P. chauveli*. *P. haughtoni* from South Africa (Cocks *et al.* 1970) and *P. chauveli* from Morocco (Havlíček 1971) can easily be distinguished from *P. crassicosta* by their smaller, more numerous costae; *P. chauveli* also has a dorsal septalium. There is considerable morphologic variation within collections assigned to *P. crassicosta*, and the specimens under study fit well within the morphologic variability that has been described. The type specimen of *P. crassicosta* is from Sweden and specimens from Sweden usually have four costae in the sulcus (see Bergström 1968); there is but a single strong costa and two weaker ones in typical specimens from Percé. Specimens from Great Britain (see Temple 1965) more nearly resemble the Percé assemblage as they commonly have only three costae in the sulcus, but the ribs which form the dorsal fold bifurcate about 5 mm from the beak rather than at about 12–15 mm as in specimens from Percé. Bergström (1968) reports that specimens from Sweden have a dorsal median ridge that does not reach mid-length. English specimens have a dorsal median ridge that extends to the anterior margin (Temple 1965) as it does in specimens from Percé. The anterior portion of the ridge is, however, merely the impression of the median interspace, and there may be confusion as to whether or not it should be termed a median ridge.

The species has also been reported from the Hirnantian fauna from Kildare, Ireland (Wright 1968). Illustrated specimens assigned to the species from the Kosov Formation of Bohemia (Marek and Havlíček 1967) are quite distinctive and belong to a separate species. The Bohemian fossils have finer, more numerous costae (as many as fifteen costae on the flanks) than is known in *P. crassicosta*. In addition, some costae on the flanks bifurcate, and the fold and sulcus are not as well defined. Neuman (1968) reports that *Plectothyrella* sp. is present in Aroostook County, Maine. Bergström (1968) suggested that *Aratanea monodi* from ?Silurian rocks in the Sahara is similar to *P. crassicosta*. The species differs in having weaker ribbing and an elongate rather than transverse shell.

EXPLANATION OF PLATE 110

- Figs. 1–5. *Eostropheodonta siluriana* (Davidson). 1, mould of ventral interior of GSC 42233, $\times 2.0$. 2–3, enlargement of the mould of the hinge area showing striated teeth and the entire ventral interior mould of GSC 42234, $\times 5.0$, $\times 2.0$. 4, ventral interior of GSC 42235, $\times 1.75$. 5, dorsal interior mould of GSC 42236, $\times 3.0$.
- Figs. 6–21. *Plectothyrella crassicosta* (Dalman). 6, dorsal exterior with a cornulitid, between two costae, left of centre, GSC 42237, $\times 1.5$. 7, ventral exterior of GSC 42238, $\times 1.5$. 8–9, posterior and lateral exterior of GSC 42239, $\times 1.5$. 10–11, dorsal and ventral exteriors of GSC 42240, $\times 1.5$. 12, posterior of GSC 42241, $\times 1.5$. 13, posterior view of the inner mould of the conjoined valves of GSC 42242, $\times 1.75$. 14, posterior view of the inner mould of the conjoined valves of GSC 42243, $\times 1.75$. 15, posterior view of the inner mould of the conjoined valves of GSC 42244, $\times 1.75$. 16, posterior view of a dorsal valve showing hinge sockets, inner socket ridges, and broken crura, GSC 42245, $\times 3.0$. 17–19, ventral, dorsal, and lateral views of the internal mould of GSC 42246, $\times 1.75$. 20–21, ventral inner mould and a lateral view of the same specimen, GSC 42247, $\times 1.75$.
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